Nonlinear Classical Fields

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Abstract

We regard a classical field as a medium and so the additional parameter, the velocity of field, appears. If the one regards as a potential then all self-energies become finite. Electromagnetic, mechanical, pionic and somewhat gluonic fields are regarding.

Contents

1 Foundation

Internal contradictions of classical field theory are well known. Mainly these are the infinite self-energies of Coulomb and Yukawa fields. In 1912 year G. Mie [1] considered the electron as a state of electromagnetic field with main goal to eliminate the infinite self-energy of Coulomb field. His work gives the strong impulse for development of field theory and it has been created many works in this direction. But always the models were contradicted at least with one of general physical principles. For example, in Born -Infield model the analyticity principle was not fulfilled. In work of a French physicist [2] near 1972 year the current of a field was constructed but without C-symmetry. All these are because it is impossible to build the four-vector of electromagnetic current within the framework of electromagnetic field parameters only. Most texts on quantum electrodynamics, such as Landau-Lifschitz book (fourth paragraph), describe this impossibility in details.

Hence one of the ways for construction of a model for electromagnetic field without internal contradictions is to take into account an interaction of electromagnetic field with other fields. This task in area of quantum field theory

was done where the electromagnetic and week interactions were connected in single electroweak interaction.

In classical field theory as well as in area of low energy nuclear physics the infinite self-energies of fields remain. In this article the extension of classical field theory is considering with main goal to avoid the infinite self-energies of classical fields.

Main idea is following.

In general case any physical field has non-zero density of the mass. Therefore, any field has additional parameter, U, it is the four vector of the field velocity. The velocity or, for relativistic system, four velocity are usual parameters in physics, typically they are regarding as the properties of the particles. About a field velocity implicitly and always is assumed that it is equal to light velocity. This is doubtful because, for example, the electrostatic field of a resting particle has the three velocity equal to zero. We will regard the four velocity of a field as local parameter and so $U = U(x)$. Only in case when the field is continual variety of point-like not interacted between themselves particles the condition $U^2 \equiv 1$ is valid. In other words, a field is considering as special medium with two local parameters, they are the potential and four velocity of the field.

However, as parameter the four velocity exists for any physical object and in any case it is the essential quantity. At construction of any theoretical model for physical object, in today physics this means the lagrangian building, this parameter needs take into account. If this has done then either the four velocity is external parameter, similar to forces in Newtonian mechanics, or it is internal parameter. In last case the simple way is visible to reach up the complete system of differential equations. It is the consideration of $U(x)$ itself as a potential of some field. Then kinetic term, $(\nabla U)^2$, in lagrangian of a field removes all problems with setting the full and close equation system. Below the local four velocity of a field is regarding as a potential of some field which we call w-field.

Let us attempt to comprehend the physical meaning of this w-field. The tensions (forces) of the w-field are following (Clifford algebra, [3] and [12] [11], always is using)

$$\nabla U = \nabla \cdot U + \nabla \wedge U$$

$$\nabla \cdot U = \partial_0 U_0 + \overrightarrow{\nabla} \cdot \vec{U}$$

$$\nabla \wedge U = -\partial_0 \vec{U} - \overrightarrow{\nabla} U_0 + i_c \overrightarrow{\nabla} \times \vec{U}$$

In case $U^2 = 1$ the quantity $-\partial_t \vec{U}$ is usual mechanical acceleration with oppo-

site sign. Hence the w-field forces contain inertial forces. In typical case the square of four velocity is not equal to unit. The examples are: for scalar photons (these are electrostatic fields) $U^2 > 0$, for longitudinal photons (these are magnetic fields) $U^2 < 0$. We may feel almost certainly that by physical meaning the w-field is bearer of inertial (typically virtual) forces and expect that these forces create barrier which do not permit the concentration of a field in point-like object with infinite self-energy as it is in standard theories of interactions via fields.

Internal contradictions of classical field theory are sufficient for introducing of new essence. If we do not wish to do this then w-field may be regarded as representation, of course incomplete, of week forces in area of classical physics. For simplest approach, used in facto, the four velocity of a field is an external parameter.

If take into account the existence of w-field then it is not hard to build the lagrangian of fields (in other terminology - the Lagrange density of fields).

However, before the lagrangian construction we regard what is the coherence condition and some properties of wave function.

2 Coherence condition

Formally, this is trivial thing that is more simply understood in examples.

Regard the scalar field with potential $s(x)$ in one dimension space $x > 0$. The lagrangian of the field take as following

$$L = \frac{s'^2}{2} + ss'^2$$

The variation of the lagrangian is

$$\delta S = s'\delta s' + s'^2\delta s + 2ss'\delta s'$$

It is the sum of few terms and so more then one solution of variation task exist. Regard some of these solutions.

In case

$s'' = 0$

$s = a + bx$

the coherence condition is following

$$\int (s'^2\delta s + 2ss'\delta s')dx = 0$$

The variations in class of linear functions are

$\delta s = \delta a + x\delta b$

where $\delta a, \delta b$ are free numbers. Then

$$\int \left[b^2(\delta a + x\delta b) + 2b(a + bx)\delta b\right] dx = 0$$

Hence $b = 0$ and by physical meaning this is the vacuum state of the field.

Another solution is

$s'' = s'^2$

$s = a - ln(b + x)$

Coherence condition for this state

$$\int [a - ln(b + x)] \frac{dx}{(b + x)^3} = 0$$

connect between themselves the integration constants.

Next state is

$s''(1 + 2s) + 2s'^2 = 0$

$s + s^2 = a + bx$

with coherence condition

$$b^2 \int (\delta a + x\delta b) \frac{dx}{(1 + 2s)^3} = 0$$

In this state $b = 0$ and it is another vacuum state because the potential constants of states differ.

Generally used equation is

$$s'' + 2(ss')' = s'^2$$

without any restrictions for integration constants.

We see that single field with self-interaction exits in few states. Additionally, if some parameters are the fixed constants then variations of the ones are equal to zero and the coherence conditions for such parameters are automatically fulfilled (for example, electric charge is not variable constant). The coherence condition is strong tool for theoretical physics but it is unknown for most physicists.

3 Wave function and boundary conditions

For bound states of a particle in spherical symmetrical field the radial part of wave function take as following

$$F = CR^B \prod_0^N (R - R_i) exp(DR)$$

where C, B, R_i, D are the constants. In some cases the some of wave function zeros may be not single.

This form of wave function is settled on Sturm-Liouville oscillation theorem and might be considering as a generalization, or as a simplification, or as an extension of the one. Remark, in general case the coefficient C is finite, without zeros anywhere, analytical function on real R-axis which runs to constant on infinity. For physicist the infinity means the big, compare with some scale, distance. If the Taylor series of a function has arbitrary radius of convergence on real R-axis and on infinity the function is equal to constant then this function is constant anywhere.

The analyticity principle forced such type of wave function for Coulomb-like potentials. For example, in case of oscillatory potential the wave function on infinity has other behavior, $\sim exp(DR^2)$. So the main source of information about a system is contained in polynomial part of wave function. For some types of differential equations such solutions were known before the quantum mechanics appeared.

At first look this is trivial thing but the direct solution of differential equation is fruitful because the working with algebraic equations is more easy.

Let us determinate the additional boundary conditions for wave function in case when the potential of a field has a singularity in area of small distances. The exact mathematical solution of any equation is not the exact physical solution of the one. Have we deal with linear or nonlinear Coulomb field, or with any other field, always the area of small distances is unknown land. In this area all known and unknown forces are working. For example, the usual Coulomb potential has in center the singularity, e/R, which is non-physical because the one is not existing in nature, so it is true to regard the Coulomb potential on infinity only but not as the one having the singularity in center. For microscopic system the quantities that are visible on infinity have physical sense. In other words, for such systems the boundary conditions are invoked on infinity.

For this doing the Schroedinger equation divide on wave function, this means that the logarithmic derivative of wave function is using, and multiply the expression on R^X, where X is natural number. Then run the distance to infinity. Because on infinity the C-parameter is constant we get $X + 1$ algebraic equations, the ones fixed the unidentified parameters of wave function.

Which must be the number of these restrictions? It is must be equal to

number of unknown parameters. For example, count the ones for upper wave function. Here are the N unidentified wave functions zeros, constants D, B and energy E. For this case the degree of the multiplier is $X = N + 2$.

However, we may include in this list the parameters of the potential. If differential equation determinate all unknown constants it is well. If for some parameters the solutions did not exist then corresponding constants are regarding as external quantities. For almost all of this paper, the parameters of the potential consider as the externals.

Taking these boundary conditions we avoid the uncertainties connected with knowledge of physical quantities in not physical area of small distances. And this looks, because of simplicity, as trivial but only looks. Too widely the contradicting correlations between the parameters of the potential and wave function used to use. From these boundary conditions follow that a states with more wave function zeros contain more information about internal structure of the object. In other words, the precise measurements of energy levels may replace the high energy scattering experiments.

4 Nonlinear electromagnetic field

4.1 Lagrangian, current, Maxwell's equations

The lagrangian [4] of the pair interacting between themselves fields can be written as following

$$L = L_1 + L_2 + L_3$$

We regard the electromagnetic field with its shadow, the w-field, in area that does not contain any particle. As usually, this area is the whole space-time.

Four potential of electromagnetic field, $A(x)$, with tensions

$$F = \nabla \wedge A = \vec{E} + i_c \vec{H}$$

is restricted by Lorentz gauge condition $\nabla \cdot A = 0$

The lagrangian of free electromagnetic field is well known, namely

$$L_1 = \frac{F^2}{8\pi c}$$

Here in general case needs denominate the Dirac conjugation above of the one multiplier, for simplicity this sign is omitting.

The lagrangian for free w-field let us take in similar form

$$L_2 \sim (\nabla U)(\nabla U)$$

Quadratic dependence upon tensions for lagrangian of free electromagnetic field needs for compatibility with experimental Coulomb low. But for free w-field such form of the lagrangian is the assumption and it is strong assumption.

At first look about the interaction lagrangian nothing is known. It is true in general case but for electromagnetic field it is known enough. The four vector

$$\frac{\delta L_3}{\delta A} = J$$

is the density of current for electromagnetic field. For simplicity below we call this four vector or current, or jet. It is the source of electromagnetic field.

From Bohr correspondence principle the jet is linear function of four velocity and at all transformations the current has exactly the properties of four velocity. General form of such quantity is following

$$J = c_1 U + c_2(FU - UF) + c_3 FUF$$

where c_n are scalar functions which are independent upon velocity four vector. From gradient symmetry of electromagnetic field the ones depend on electromagnetic field tension F only.

The phase of any physical quantity is relative. This condition gives two restrictions. First limitation is $c_2 \equiv 0$. Second restriction is for argument of the coefficients - the scalar variable is F^2F^2 (one multiplier is conjugated).

Because here no the elementary particles with electric charge the condition $c_1(0) = 0$ must be valid. For usual transverse waves the current of the field is equal to zero that at once confirms this restriction.

Then in first not trivial approach the jet of electromagnetic field can be written as

$$J = \frac{c}{4\pi g} FUF$$

where the constant g determinate the scale of electromagnetic potential. This jet of electromagnetic field needs to compare with usual, eU, jet of a particle if the questions about C-symmetry arise.

For a current of w-field, $\delta L_3/\delta U$, all above arguments are true. Only the restriction on first coefficient is questionable, the interaction lagrangian may contain the term $L_3 \sim U^2$. For simplicity the self-interaction of w-field is neglected.

Four velocity is dimensionless quantity so it is convenient to take the potential of electromagnetic field in dimensionless form. It is

$$A(g, x) = gA(y = \frac{x}{a})$$

where g, a are the scales of the potential and length.

Correspondingly, the simplest action for electromagnetic field, which has the w-field as shadow and does not contain any charged particle, is following

$$S = \frac{e^2}{8\pi c} \int \left[(\nabla F)^2 + k^2 (\nabla U)^2 + 2A \cdot (FUF) + qU \cdot (FUF) \right] d^4 y$$

where all quantities after integration sign, including the variables of integration, are dimensionless.

This action does not contradict with any general physical principle. The scale invariance of this lagrangian is general property of any model for fields without external particles. By construction the validity area of this lagrangian is $O(F^4)$ and because the scale parameter is external quantity for description of macroscopic as well as microscopic systems the model can be applied.

Owing to constriction the jet is not variable by electromagnetic potential and the Maxwell nonlinear equations for dimensionless quantities are following:

in four-dimensional form

$$\nabla F = FUF$$

or, the same, componentwise

$$\nabla \cdot F = FUF$$

$$\nabla \wedge F = 0$$

in usual three-vector form

$$-\overrightarrow{\nabla} \cdot \vec{E} = u_0 (E^2 + H^2) + 2\vec{u} \cdot (\vec{H} \times \vec{E})$$

$$\overrightarrow{\nabla} \cdot \vec{H} = 0$$

$$-\partial_0 \vec{E} + \overrightarrow{\nabla} \times \vec{H} = \vec{u}(E^2 + H^2) + 2u_0 (\vec{H} \times \vec{E}) - 2\vec{E}(\vec{u} \cdot \vec{E}) - 2\vec{H}(\vec{u} \cdot \vec{H})$$

$$\partial_0 \vec{H} + \overrightarrow{\nabla} \times \vec{E} = 0$$

There always exist the solutions with potentials equal to constant anywhere. By physical meaning the ones are the vacuum states of fields.

The bevector of electromagnetic tension, Maxwell equations and Lorentz gauge condition are not changeable at transformation

$$A \to A + constant$$

Therefore for pure electromagnetic system the value of electrostatic potential on infinity is free number.

Using the coherence condition this equation system can make to be closed.

4.2 Closing equations of the field

Simplest state of electromagnetic field is that where the w-field is in vacuum state. In this case, taking into account the equality

$$A \cdot \big(FUF\big) = U \cdot \big(FAF\big)$$

the equation for four velocity is

$$\nabla^2 U = 0$$

Because this is the isolated equation the coherence condition take in form

$$\int (\delta U \cdot (FAF + qFUF)) d^4 y = 0$$

$$\int \delta_A J \cdot (2A + qU) d^4 y = 0$$

Next states we call the coherent states. In this case the equation for four velocity is

$$k^2 \nabla^2 U = FAF$$

with restrictions

$$\int \left[(2A + qU) \cdot \delta_A J + qU \cdot \delta_U J\right] d^4 y = 0$$

All other states involve in equation system the self-interaction of w-field, for simplicity we discard the ones here.

In this way the system of differential equations is completed.

Now regard the nonlinear Coulomb field.

4.3 Nonlinear Coulomb field

This is spherically symmetrical electrostatic field. Dimensionless potentials and the space variable of the field denominate as following

$$s(x) = A_0(x),\ u(x) = U_0(x),\ x = \frac{a}{R}$$

In this case the Maxwell equation is following

$$s'' = us'^2$$

where the denomination of scalar velocity is clear.

This electrostatic field has non-zero electric charge and non-zero density of electric charge what are the new phenomena not only for theory of classical fields.

In case of a system with full positive electric charge equal to unit the solution for tension is following

$$s' = exp \int_{s_0}^{s} u(s)ds = [1 - \int_0^x u(x)dx]^{-1}$$

In physical area, it is the area of big distances, the electrostatic potential is following

$$s = s_0 + x + s_2\frac{x^2}{2} + s_3\frac{x^3}{6} + ..$$

or for physical potential of the system with electric charge e

$$A_0 = \frac{es_0}{a} + \frac{e}{R} + \frac{eas_2}{2R^2} + ..$$

In this expression the coefficients s_i depend upon interaction constant of free w-field and from vacuum potential of electrostatic field. So implicitly the vacuum potential of electrostatic field is observable. In this point the nonlinear model differ from linear model where vacuum potential is free number. Of course, for different states these are different constants.

When the w-field is in vacuum state the equation for scalar velocity is the free field equation, namely

$$u'' = 0$$

$$u = u_0 + bx$$

Any physical field has finite self-energy. Hence the constant $b = 0$ and electrostatic potential in this state is

$$s = s_0 - \frac{1}{u_0}ln(1 - u_0x);\ \ u_0 < 0$$

Coherence conditions for these states are

$$\int (s + qu_0)s'^2 \delta u_0 dx = 0$$

$$\int (2s + qu_0)s' \delta s' dx = 0$$

then

$$u_0(s_0 + qu_0) = 1$$

$$u_0(2s_0 + qu_0) = 3$$

For system with positive electric charge the scalar velocity $u_0 = -1$. So $s_0 = -2$ and $q = -1$. This is very exotic state, below only the coherent states of electromagnetic field are regarding .

For coherent states the equation and solutions for scalar velocity are

$$k^2 u'' = ss'^2$$

$$u = -\frac{s}{k} + 2\sum_n \frac{1}{s - s_n}$$

with the equations

$$s_n = 2k \sum_{i \neq n} \frac{1}{s_n - s_i}$$

for determination of Hermitian numbers s_n, while the electrostatic tensions of these fields are

$$s' \sim \prod_0^N (s - s_n)^2 exp(-\frac{s^2}{2k}); \quad s'(0) = 1$$

so there are the variety of states similar to Glauber states.

For these coherent states always must be $s_0 > s_N$ then the self-energy of free w-field is finite number.

From physical reason, any motion on infinity is free motion. Correspondingly, the scalar velocity, u, on infinity has one of three possible values $u_+ = \{-1, 0, +1\}$. For states with positive electric charge $du/ds < 0$ and so in case $u_+ = +1$ these states have complicated electromagnetic structure because the density of electric charge change the sign in internal area of field.

Another example is the nonlinear electrostatic field of light nucleus. In nucleus the scalar velocity, u, depends upon parameters of the electromagnetic

and strong fields. In light nucleus the motion of nucleons is governed by strong interaction mainly. The distribution of nucleons is almost constant and their velocities are small compare with light velocity. Correspondingly, the scalar velocity of electromagnetic field in light nucleus is constant for first approach. In other worlds, in equation for determination of electrostatic potential the scalar velocity is external parameter which is equal to zero in external area and it is the constant in internal area of nucleus. However, the parameter u is not necessary equal to unit because a nucleon moves in cloud of virtual bosons but not in empty space. If b is the radius of light nucleus then the electrostatic tension is

$$E = \frac{eZ}{R} \qquad u_0 = 0 \qquad R > b$$

$$E = \frac{d}{R(R+b)} \qquad u_0 = const \qquad R < b$$

By physical meaning the constant d is the polarization of internal nucleus medium.

For that reason the distribution of electric charge in light nuclei at small distances essentially differs from the one in heavy nuclei.

Remark that for nonlinear Coulomb field the Earnshaw theorem may be not valid because the laplacian of electrostatic potential is not equal to zero.

Additionally, let us regard qualitatively the electron levels in nonlinear Coulomb field and the nonlinear electromagnetic waves.

4.4 Electron levels

The spin effects are essential here and the Dirac equation must be using. Electromagnetic field itself is four vector field but it is joining with spin framework. For example, electrostatic field of proton in general case is the sum of two terms with spins equal to 1/2 and 3/2. To avoid this, perhaps purely technical barrier, regard the electron connecting with alpha particle. The one has zero spin and the variety of data exist for He II levels. The Dirac equation for such systems has usual form

$$(i\nabla - eA)\Psi = m\Psi$$

$$c = 1,\ \hbar = 1$$

Let us go to usual three-spinors, separate the angle dependence of wave functions and convert two equations for two radial wave functions into one equa-

tion. Then the Schroedinger-like equation appears as

$$F'' + \frac{2}{R}F' + \frac{F'V'}{W-V} = \left[\frac{l(l+1)}{R^2} - \frac{fV'}{R(W-V)} + 2EV - V^2 + m^2\right] F$$

where E, V, m, j, l are the energy, potential energy, mass, momentum and orbital momentum of the electron; $W = E + m$; and $f = \{-l,\ (l+1)\}$ for $j = \{l + 1/2,\ l - 1/2\}$.
In this form the analytical properties of wave function are more realize.

Let us deviate from consideration of nonlinear field and regard the electron levels in the hydrogen for usual Coulomb field. In this case the denominator

$$W - V = W + \frac{\alpha}{R}$$

has single zero in the point $R_0 = -\alpha/W$ and two terms in the equation are singular. Thus we take the electron wave functions as

$$\Psi \sim R^B (R - R_0)^D \prod_{n=1}^{N} (R - R_n) exp(AR)$$

One of the emerging algebraic equation, $D^2 - 2D = 0$, has two solutions. The case $D = 0$, which corresponds to cancellation of the equation singularities, refers to well known situation available in all quantum mechanics textbooks, there the variety of main quantum number is {1,2,...}. If $D = 2$ the wave function has double zero and the main quantum number runs the variety {3,4,...}. So these novel states with main quantum number $n > 2$ are degenerated with the first ones while the states without or with one single zero of wave function are not degenerated. External electromagnetic field can take off this degeneration. For some reason the implicit assumption about singularities cancellation is used commonly, the existence of the solutions with double zero of the electron wave function was not considered, at least this is in accessible for me articles. Below we will regard the $n < 3$ states so the problem of levels degeneracy has no place. This piece of text is produced for slipping in the direction of physics after deep involving in the job of the digger for laying the water-pipe.

Now go back to nonlinear Coulomb field.

According to boundary conditions it is possible to make the following replacement

$$V \to V_0 - \frac{Z}{R} - \frac{Zau_0}{2R^2} - \frac{Za^2 s_3}{6R^3} + ..$$

and these are not the singularities in zero.

In Dirac equation the energy of electron and the term V_0, by physical sense the last is the interaction energy of the electron with vacuum, always are joined so below the last term is omitted when it itself is not required. Because the electric charge number and the fine structure constant are undivided the denomination Z instead of αZ is using frequently.

For calculation of unknown parameters the first four equations are

$$D^2 = m^2 - E^2$$

$$D(N + B + 1) = -EZ$$

$$B^2 + B + D(\frac{Z}{W} + 2\sum R_i) + 2BN + N^2 + N = l(l+1) - Z^2 - ZEas_2$$

$$D\left[\frac{Z}{W}(as_2 - \frac{Z}{W}) + 2\sum R_i^2\right] + 2(B+N)\sum R_i + (B+N+f)\frac{Z}{W} =$$

$$= -Z^2 as_2 - \frac{1}{3}ZEs_3 a^2$$

Neglecting by spin effects the He I levels regard roughly. Here the assuming scale of length is $ma = d/Z + ...$ Correspondingly, the binding energies of states with maximal orbital moment (N=0) are following

$$\varepsilon = \frac{m\alpha^2}{2}\left[1/2 + \sqrt{(l+1/2)^2 - du_0}\right]^{-2}$$

In He I the electric charge density on infinity is negative hence $u_0 = +1$ and the binding energy of the electron is bigger compare with linear model. From ionization energy data we roughly have $u_0 d = 0.2$ so with increasing of moment the spectrum quickly became hydrogen-like. The picture is true.

Regard the electron levels in He II (the alpha particle with one electron). Here on infinity the density of electric charge is positive and so $u_0 = -1$. Because electric charge is not concentrating in point all levels have shift up compare with levels in usual Coulomb field. Strong interaction between nucleons in nucleus ties up the particles - and so the electric charge with the ones - what may compensate nonlinear effects. Such is qualitative picture.

For calculation it needs to know the order of the scale parameter. It is

$$ma = .. + \frac{a_1}{Z} + a_0 + dZ + ..$$

Certainly, for He II in this sum the left coefficient is zero and the last is not zero. With middle coefficient is an uncertainty but from equations the one may put equal to zero. Remark, when asymptotic procedure of solution searching is using then we have not single-valued result and for separation of physical solutions it needs to use the correspondence principle. So the B-coefficient takes as following

$$B = j - \frac{1}{2} - \frac{Z^2}{2j+1} + bZ^2 + ..$$

correspondingly, the binding energy of the electron is following

$$\frac{\varepsilon}{m} = \frac{Z^2}{2n^2} - \frac{3Z^4}{8n^4} + \frac{Z^4}{n^3(2j+1)} - \frac{bZ^4}{n^3}$$

$$n = N + j + \frac{1}{2}$$

In states with maximal momentum (N=0) the nonlinear addition to binding energy is $b(2j+1) = -du_0$. The comparison with data and linear approach show that as the sign as the momentum dependencies of the supplement are true.

But let us regard the 2S, 2P states with momentum $j = 1/2$. In linear model these states are degenerate as any levels on fixed shell with equal momentum and opposite parity. In both these states the wave function has one zero. However, the ones have different order: not relativistic

$$mR_S = \frac{2}{Z} + ..$$

for S-state and relativistic

$$mR_P = -\frac{3Z}{4} + .$$

for P-state. Correspondingly, $b_S = -du_0 + ..$ in S and $3b_P = -du_0 + ..$ in P states.

So binding energy of electron in S-state is less of the one in P-state. This is the Lamb shift phenomenon. The value of Lamb shift is equal to $-u_0 dZ^4 mc^2/12$. From quantum electrodynamics calculations and from data

the value of Lamb shift is $0.41\alpha Z^4 mc^2$. This means that the value of parameter $-du_0$ is not sufficient for fitting the ionization energy of He II ion, the interaction energy of electron with vacuum can be taken into account and so the vacuum potential of electrostatic field for this system is directly observable quantity. Because at the estimation of the energies the s_3 and next coefficients were not working this result is grounded on analyticity principle mainly.

In usual model only the electric charge is external parameter, as result the electromagnetic system has zero size and infinite self-energy. In nonlinear model the charge and the scale of length are external parameters, all other quantities, including the self-energy of a field, are calculable. There has been the similarity with quantum electrodynamics where the electric charge and electromagnetic mass, the last determinate the space scale and vice versa, are external parameters of electromagnetic system.

4.5 Nonlinear electromagnetic waves

For classification of electromagnetic field states the signs of the invariants

$$E^2 - H^2;\ \vec{E} \cdot \vec{H};$$

are using. In nonlinear model somewhat another classification of the states is more convenient. Indeed, the square of electromagnetic jet is

$$J^2 \sim [(E^2 - H^2)^2 + (\vec{E} \cdot \vec{H})^2]u^2$$

Therefore, the states of the field are distinguishable via $u^2 = u_0^2 - \vec{u}^2$ sign.

The states with $u^2 \equiv 0$ contain the usual electromagnetic waves. In case $u^2 > 0$ the field has electric charge, these are the electric states of the field. If $u^2 < 0$ then these are the magnetic states of field, the ones have the electric charge equal to zero.

Correspondingly, at least the local coordinate systems exist where: the charged states have positive energy and zero impulse; the magnetic states have zero energy and not zero impulse. Of course, these did not mean that the magnetic states are moving with super light velocity. The example is the usual electric current in usual conductor. For magnetic and electric states the attribute 'velocity' has different physical meaning.

Typically, the electromagnetic waves are states without electric charge and with periodical phase. Thus nonlinear electromagnetic waves are magnetic states of the field.

For description of nonlinear waves it is conveniently to choose the coordinate system where the scalar part of electromagnetic potential is equal to

zero. From Maxwell nonlinear equations follow that the four vectors A, u are collinear then in appropriate coordinate system both scalar potentials are equal to zero, $A_0 = 0, u_0 = 0$.

It is conveniently take the four potentials of the field for flat electromagnetic waves as following

$$A = A(x)\gamma_y exp\{i(\omega t - kz)\}$$

$$u = -u(x)\gamma_y exp\{i(\omega t - kz)\}$$

With such choice of potentials the four tension of electromagnetic field is given by expression

$$F = (-i\omega A e_y + i i_c k A e_x + i_c A' e_z)\, exp\{(i(\omega t - kz)\}$$

what is more complicated form compare with usual description of the vector field without usage of Clifford algebra. However, the needing equations contain the amplitudes of potentials so this complication has no matter. If we wish divide the tension into electric and magnetic parts then the suitable phases need to take. The phase multiplier in potentials creates same theoretical trouble because this convert the vector field in mixture of vector and pseudo-vector fields. For simplicity we go round of that by usual manner - rewriting the definition of jets as $FuF \to Fu^+F,\ FAF \to FA^+F$.

Simplest waves are those where the w-field is in free state. Nevertheless, we consider the coherent states of the field.

For plainness, we regard only slow waves (put $\omega = 0$) and denominate the dimensionless amplitudes of the potentials as following

$$A(kx) = g\sqrt{k_{int}}p(s)$$

$$gv(s) = \sqrt{k_{int}}u(kx)$$

$$s = kx$$

where k_{int} is the interaction constant of free w-field.

Then from nonlinear equations for coherent states of the field the equations for calculation of dimensionless amplitudes follow in form

$$p'' - p = v(p'^2 - p^2)$$

$$v'' - v = p(p'^2 - p^2)$$

The symmetry $p(-x) = p(x)$ and boundary $p'(\infty) = 0,\ p(\infty) = constant$ conditions are taking that is suitable for paramagnetic waves. The last condition looks surprisingly because then the density of field energy on infinity contains a constant terms. However, the appropriate choice of interaction constant q in the lagrangian of electromagnetic field takes off the problem. In paramagnetic waves the local currents are parallel therefore, on ground of Ampere low, these waves are stable.

Few simple exact solutions of these equations exist. First is trivial $p \equiv v \equiv 0$ and it correspond to pure vacuum state of field. Second is $p \equiv v \equiv 1$, because the phase of fields is not zero these are the usual waves with fixed constant amplitudes. The solution $p \sim exp(\pm x),\ v \sim exp(\pm x)$ represent the free states of field, in this case the equations $p'' = p, v'' = v$ are equations of free field and the interaction between electromagnetic and w-field is absent.

Hence at least the free coherent nonlinear electromagnetic waves exist in the model. In these waves the field is concentrating near surface $x = 0$ and they did not have the internal structure along x-axis.

Apparently, the more complicated waves are here. For their detecting consider the example. Let us take the simplest connection, $v \equiv p$, between electromagnetic and w-field. By physical meaning the velocity parameter, v, is the polarization of vacuum with nonlinear dependence upon electromagnetic potential. The solution $p \equiv v$ correspond to linear connection between the polarization of vacuum and potential of electromagnetic field. For this case the first integral is

$$p' = \pm\sqrt{p^2 + C\,exp(p^2)}$$

and here are periodical solutions for potential if the first integration constant, C, is small negative number - then under square root expression is positive in area $p_- < p < p_+$. With conditions $p'(0) > 0$ the amplitude of potential increase at moving along s-axis and reach the value $p = p_+$ in same point $s = s_1$. After this point we may or put $p \equiv p_+$, or change the sign of the derivative. In last case the amplitude grow down to value $p = p_-$ in point $s = s_2$. These circles may be repeated not once but on big distances need to put $p \equiv p_+$, or $p \equiv p_-$. The situation is similar to usual trigonometric states where $p' = \sqrt{1 - p^2}$, therefore $p(x) = sin(x)$, or $p(x) \equiv \pm 1$. The energy of these states is the sum of the bits that gives additional chance for stability of these waves.

For axial symmetrical waves the electromagnetic jet is flowing along the axis of symmetry, or revolving about of the one. In first case the electromagnetic potential for slow waves take in form

$$A = A(\rho)\gamma_z exp(ik_1\varphi)$$

and similarly for potential of w-field. The variable ρ convert to variable $x = ln(\rho)$ then the equations for determination of field amplitudes are exactly the same as for system with flat symmetry. Then, for example, the field of free slow paramagnetic axial symmetrical wave is condensed near surface $\rho = 1$ what is similar to skin effect for usual neutral electric current in conductors.

In this way, the states of nonlinear electromagnetic field in form of nonlinear waves exist on paper. These states have richer structure than the usual electromagnetic waves. For theirs existence the external mechanical walls are not demanding.

Nonlinear waves interact with external electromagnetic field. Indeed, in this model all fields are interacting, however, not with themselves but with w-field. If take into account that any external field has fixed phase then it is easy to build the simplest lagrangian for interaction of nonlinear wave with external electromagnetic field. Because the usual electric jet itself is magnetic state we expect that all effects observable at spreading of usual electromagnetic waves via mechanical medium can be observable at spreading of nonlinear waves via as an external electromagnetic field as a medium because the last is the pattern of external field.

4.6 Numerical test of the model

Electronic spectrum of light ions is known with $10^{-7}eV$ exactness so the explicit calculations need to perform for testing the validity of nonlinear Coulomb potential. The He II ion, which is simplest among others, take for numerical testing. All constants are taking from NIST tables [7], in this subsection all energies and masses are presented in electron-volts. The fine structure constant is $\alpha = 7.297352568 \cdot 10^{-3}$. The electron, proton, neutron masses are

$$0.5109988918 \cdot 10^6;\ 938.2720029 \cdot 10^6;\ 939.565360 \cdot 10^6$$

Binding energy of alpha particle is $28.295674 \cdot 10^6$, thus the reduced mass of electron in He II is $m = 0.510928873 \cdot 10^6$. For our goal these data have the extra precision.

From Lamb shift data it is visible that the dimensionless scale parameter $ma = \alpha Zd$ has order $d \sim 0.01$. Correspondingly, for connection with Lamb

shift the precision of calculations for electron binding energy of order $O(\alpha^6)$ is enough, the B-coefficient needs to know with $O(\alpha^4)$ exactness.

Because the lagrangian itself is approximate construction the states with no more then one knot of wave function are considering.

Dimensionless scale, d, and the interaction constant of free w-field, k, are adjusting parameters. In first approach, when the motion of nucleons in nuclei is not counting, the nucleus effects are implicitly in adapted scale parameter.

With these conditions the calculated He II spectrum for states with maximal orbital moment in each shell (these are the states without knots of wave function) has coincidence with data that is not acceptable.

What is not true?

May be the nonlinear field? Dimensionless potential of Coulomb nonlinear field for N=0 states is

$$s = s_+ + \frac{Q}{R} - \frac{Qa}{2R^2}$$

and this form of the one follow directly from analyticity principle, only the sign of third term is resulting from nonlinear model. Because the scale parameter is fitting number this contribution of nonlinear model has no matter. For mistrusting in analytic principle, in addition the one is tightly connected with causality principle, we have no any reason.

Is Dirac equation incorrect in area $10^{-13}cm$? This is possible. However, the one work well enough in area of low energy nuclear physics where the scale is the same.

May be somewhat was missing in calculations? Yes, at estimation of electron levels in previous subsection we loose the w-field itself. In this model the electron moves in two fields. Electrostatic field act on the charge of the electron and it will be not strangely if the w-field act on the mass of the electron. By physical meaning the w-field may interact with any mass. Therefore, before reject the Dirac equation as not valid for electromagnetic interaction in area of small distances, we may attempt take into account the interaction of the electron with w-field. About this interaction nothing is known. The straightforward inclusion of a new terms in Dirac equation create, because of asymptotic conditions, the renormalization of charge. This is dangerous situation for any theoretical model because the measurement of fine structure constant carry out mainly from atomic spectroscopy experiments, short review of using methods is in [13]. However, it is plausible that in result of this mass interaction the effective mass of the electron is created. Then simplest way for counting of unknown forces is making the replacement in the expression for electron binding energy as following

$$m \to m + \delta m,$$

$$\frac{\delta m}{m} = g_1 a\overline{R^{-1}} + g_2 a^2\overline{R^{-2}} + ..$$

where, because the mass must be not renormalizable, the 0-term in series is zero. The electron energy in nonlinear Coulomb field is possible to write as series of $\alpha^2(B+N+1)^{-2}$ terms. Then we may take

$$\frac{\delta m}{m} = \frac{\alpha^2 Z^2 g_1}{(B+N+1)^2} + \frac{\alpha^4 Z^4 g_2}{(B+N+1)^4} + ...$$

without relying on averaging procedure. Moreover, any potential that contain on infinity the 1/R term generate the coulomb-like spectrum, the electromagnetic field and its shadow have identical algebraic structure so, for avoid the appearance of additional parameters, we are taking the deformed mass in form

$$1 + \frac{\delta m}{m} = \frac{B+N+1}{\sqrt{(B+N+1)^2 - g\alpha^2 Z^2}}$$

where g is unknown constant.

In this way the binding energy of the electron is (for simplicity we omit the vacuum potential of electrostatic field that has no matter for calculation of transition energies; of course, for ionization energy the value of vacuum potential is essential)

$$\varepsilon = mc^2 \frac{B+N+1}{\sqrt{(B+N+1)^2 - g\alpha^2 Z^2}} \Big[1 - \frac{B+N+1}{\sqrt{(B+N+1)^2 + \alpha^2 Z^2}}\Big]$$

As first approach let us consider the states without and with one (N=0 and N=1) knots of wave function. We take the simplest nonlinear potential energy

$$V = -\frac{\alpha Z}{R} + \frac{\alpha Z a}{2R^2}, \quad a = \alpha Z \frac{d}{m};$$

which de facto is produced by causality principle.

Then unknown parameters find using the data for (N=0, j=l+1/2) series.

The expressions for B-coefficients are

$$B(N=0, j=l+1/2) = l + \alpha^2 Z^2 \Big(\frac{-1}{2l+2} + \frac{d}{2l+1}\Big) -$$

$$-\alpha^4 Z^4 \Big(\frac{1}{(2l+2)^3} + \frac{d^2}{(2l+1)^3}\Big)$$

$$B(N=1, j=l-1/2) = l - 1 + \alpha^2 Z^2 \Big(\frac{-1}{2l} + \frac{d}{2l+1} \Big) -$$

$$- \frac{\alpha^4 Z^4}{8l^3}$$

At dubbing of unknown parameters the different mathematical programs return the somewhat different results, for taming the fitting procedure the small, d^2, terms in B-coefficient of (N=0, j=l+1/2) states was held. For (N=1, j=l+1/2) and (N=0, j=l+1/2) states the expressions for coefficients are identical.

With

$$d = 0.05634, \; g = 0.1487$$

the He II spectrum for N=$\{0, 1\}$ states is (observable values taken from NIST tables [7])

nlj	N=1, j=l+1/2 N=1, j=l-1/2 N=0, j=l+1/2	data
2s1/2	40.8130857	40.8130871
2p1/2	40.8130301	40.8130290
2p3/2	40.8137552	40.8137552
3p3/2	48.3715051	48.3715104
3d3/2	48.3715093	48.3715100
3d5/2	48.3715808	48.3715817
4d5/2	51.0167772	51.0167797
4f5/2	51.0167794	51.0167797
4f7/2	51.0167945	51.0167948
5f7/2	52.2411401	52.2411413
5g7/2	52.2411412	52.2411413
5g9/2	52.2411458	52.2411460
6g9/2	52.9062220	52.9062226
6h9/2	52.9062225	52.9062226
6h11/2	52.9062243	52.9062244
7h11/2	53.3072441	53.3072445
7i11/2	53.3072445	53.3072445
7i13/2	53.3072453	53.3072453
8i13/2	53.5675225	53.5675227
8k13/2	53.5675227	53.5675227
8k15/2	53.5675231	53.5675231
9k15/2	53.7459683	53.7459684
9l15/2	53.7459684	53.7459684
9l17/2	53.7459686	53.7459686
10l17/2	53.8736094	53.8736094
10m17/2	53.8736095	53.8736095
10m19/2	53.8736096	53.8736096
11m19/2	mixed	mixed
11n19/2	53.9680495	53.9680494
11n21/2	53.9680495	53.9680495
12o21/2	54.0398788	54.0398788
12o23/2	mixed	mixed
13q23/2	54.0957789	54.0957788
13q25/2	—	—
14r25/2	54.1401338	54.1401338
14r27/2	—	—
15t27/2	54.1759171	54.1759171
15t29/2	54.1759172	mixed
16u29/2	54.2052032	54.2052031
16u31/2	mixed	mixed
17v31/2	54.2294747	54.2294747
17v33/2	—	—
18w33/2	54.2498145	54.2498145
18w35/2	—	—
19x35/2	54.2670281	54.2670280
19x37/2	—	—
20x37/2	54.2817247	54.2817247

The last two quantities stand to almost Rydberg states. For example and comparison, the 20Y transition energy calculated with usual Coulomb field and without mass interaction is 54.2821688.

The binding energy of ground state is $\varepsilon = V_c + 54.4177630$ and in this model it is impossible to put the constant $V_c > 0$ equal to zero. Therefore the energetic gap between the states of electron in atom and in empty space exists in this model. If so then Rydberg states can be taken for energy accumulation. The measurement of the gap is reachable with today equipment because the now observable value of the electron ionization energy for He II is 54.418 eV.

As short summary, the nonlinear model stands upon numerical test. However, the theoretical problems with including of the mass, may be the energy, interaction with w-field arise.

4.7 Hydrogen levels

The proton has not zero spin and so its electromagnetic field contains a magnetic component. This gives rise to hyperfine splitting of hydrogen levels (for examples see the article [16] and references therein). For first approach this splitting can be neglected, in this case the expression for binding energies of the electron in hydrogen is the same as for He II in previous subsection. However, the values of fitting parameters (they are the dimensionless scale of nonlinear Coulomb field, d, and interaction constant of w-field with the mass of electron, g) differ. Again the simplest nonlinear potential energy is taken as

$$V = -\frac{\alpha Z}{R} + \frac{\alpha Z a}{2R^2}, \quad a = \alpha Z \frac{d}{m};$$

and the states with maximal momentum are using for calculation of unknown parameters.

With

$$d = 0.0731;\ g = 0.20193,\ m = 0.5107207446\ MeV;\ Z = 1;$$

the transition energies for N={0,1} states are following (the data are from NIST tables [7], 1eV is the unit of energy)

nlj	N=1, j=l+1/2 N=1, j=l-1/2 N=0, j=l+1/2	exp
2s1/2	10.1988147	10.1988101
2p1/2	10.1988058	10.1988057
2p3/2	10.1988511	10.1988511
3p3/2	12.0875071	12.0875066
3d3/2	12.0875065	12.0875065
3d5/2	12.0875110	12.0875110
4d5/2	12.7485395	12.7485394
4f5/2	12.7485394	12.7485394
4f7/2	12.7485404	12.7485404
5f7/2	13.0545020	13.0545019
5g7/2	13.0545020	13.0545019
5g9/2	13.0545023	13.0545022
mixed	mixed	mixed
6h9/2	13.2207036	13.2207035
6h11/2	13.2207037	13.2207037
7i11/2	13.3209178	13.3209178
7i13/2	13.3209179	13.3209179
8k13/2	mixed	mixed
8k15/2	13.3859607	13.3859607
9l15/2 9l17/2	13.4305539	13.4305539
10m17/2 10m19/2	13.4624511	13.4624511
11n19/2 11n21/2	13.4860515	13.4860514
12g21/2 12g23/2	13.5040014	13.5040014
13q23/2 13q25/2	13.5179708	13.5179707
14r25/2 14r27/2	13.5290550	13.5290550
15t27/2 15t29/2	13.5379972	13.5379972
16u29/2 16u31/2	13.5453157	13.5453157
17v31/2 17v33/2	13.5513811	13.5513811
18w33/2 18w35/2	13.5564640	13.5564640
19x35/2 19x37/2	13.5607656	13.5607656
20y37/2 20y39/2	13.5644383	13.5644383
limit	13.5984340	13.5984340

Today observable ionization energy is 13.5984 eV and so the vacuum potential of hydrogen field compare with He II field is small. It is strange because for electrostatic vacuum potentials we are expecting the validity of superposition principle.

Let us compare the hydrogen and HeII results.

Little more best agreement with data for N=0 states of the hydrogen atom seems natural because in low energy area the structure of the proton is simple of alpha particle structure.

Well agreement with data for (N=1, j=l-1/2) states of hydrogen is surprising result. Possible treatment of that is following. Spin-orbital splitting of the levels has not dynamical origin, it is caused by algebraic structure of Dirac equation, the effective potential of R^{-2} degree is valid as for N=0 as for N=1, j=l-1/2 states. Asymptotic procedure of differential equations solution generate the series of effective potentials which are the polynomials of 1/R. At solving of Schroedinger equation by usual manner the odd degree potentials have nonfunctional analytic properties and can be discarded. When boundary conditions was settled then the way of computations is the question of the comfort only, so the restriction on potentials of odd degree can be valid as first approach.

The agreement with data for N=1, j=l+1/2 states is worse and the next effective potential (if odd degree are forbidden it is R^{-4} type of potential) needs involve in computations. For N=1, j=l+1/2 state, independently the R^{-3} or R^{-4} potential is using, the additional term in potential energy arise. It is $-\alpha s_3 a^2/(3R^3)$ where $s_3 = (us'^2)'_0 = 2 - 1/k - 2\sum 1/(s_0 - s_n)^2$. So we expect that the s_3 coefficient is negative, of α^{-2} order, constant. For hydrogen this circumstance permit the improving of the fit for 2s1/2 series. But the He II fit require the positive value of this constant. This means that motion of protons in nucleus, which decrease the repulsive forces and then increase transition energies, want to count. However, the unexpected essences are not forbidden here.

Experimental binding energies have smooth dependence upon orbital momentum. Nevertheless, the fitting of the energy is not trivial task and nonlinear Coulomb potential gives natural ground for calculation of atomic properties. Of course, the computations as hyperfine splitting as next transition energies are desirable.

4.8 Levels of Li I

Since N. Bohr, because of experimental physicists achievements, the atomic spectra did not have to become simple for theoretical calculations. To ob-

tain the correspondence with data even in case of few lines of simple atom the needing work is huge, see [17] and references therein. Of course, the computations are true if using models are true.

However, the spherical symmetrical potential energy, $V(R)$, of the valence electron in the atom, without relying on a model, on big distances can be decomposed in series

$$V = V_0 + \frac{V_1}{R} + \frac{V_2}{R^2} + ..$$

Then, regarding V_i as free parameters, anyone can perform a fit of the data and in this way to check the analyticity principle directly. I had done this for Li I 2s1nl states, which are simplest between the ones, with usage of nonlinear model for electromagnetic field which brings the independence of two coefficients only. It has been fruitlessly.

What the matter is? The analyticity principle is the hardest base of theoretical physics. The hint for escapement was found in interesting work [18] where thermodynamic formalism is applying to pure mathematical system. The solution is: global, $0 < R < \infty$, analyticity is absent, at least the single point, $R = R_0$, exists where the electrostatic potential fails to be analytic. Physical underpinning of such situation can be found easy. For clearness we regard LiI 2s1nl states only. The density of negative electric charge produced by two electrons on s-shell is $\sim exp(-\alpha R/R_0)$. Correspondingly, in area $R > R_0$ the valence electron is moving in some kind of field gas created by cloud of virtual scalar photons while in area $R < R_0$ the motion is in some kind of field liquid. So the atom is the system with internal phase structure. Of course, it was assumed implicitly that electrostatic potential of the atom is the sum of nucleus and electronic potentials, in first approach this is true.

All electrons in the atom are near mass shell, in first approach their scalar velocities, $u_0(R)$, are near unity, $|u_0| = 1$. Because the nonlinearity of negative electrostatic field is caused mainly by motion of the electrons the nonlinear Maxwell equation, $s'' = u_0 s'^2$, leads to following potential of electronic cloud

$$\varphi = -\frac{2e}{R_0} ln\Big(1 - \frac{R_0}{R}\Big)$$

where for moving the singularity in physical area the value $u_0 = 1$ was selected. Correspondingly, the decomposition of the potential in series with infinite radius of convergence is impossible and the 'exact' solutions must be found. Remark, this potential depends on $(R - R_0)$ variable. At usual consideration, when the creators of the fields are dotty particles but not the fields itself, the electron correlations dependence on $|\vec{r}_1 - \vec{r}_2|$ variable.

It is cumbersome to work with logarithmic potential and for first approximation the potential energy for last electron in Li I take in form

$$V = -\alpha\frac{3}{R} - \alpha\frac{a_1}{R^2} + \alpha\frac{2}{(R-R_0)} - \alpha\frac{a_2}{(R-R_0)^2}$$

where we held the first nonlinear terms and all scales have equal order, namely

$$a_1 = \frac{a}{\alpha m};\;\; R_0 \sim \frac{1}{\alpha m};\;\; a_2 = \frac{b}{\alpha m};$$

For logarithmic derivative, $f = F'/F$, of radial wave function, $F(R)$, the Dirac equation reads

$$f' + f^2 + \frac{2}{R}f = \frac{l(l+1)}{R^2} + m^2 - W^2 + 2WV - V^2$$

where, because of spin-orbital interaction smallness, the terms with derivative of potential were neglected; the term $W = E - V_0$ contains the energy, E, and vacuum term, V_0, which in nonlinear model is not equal to zero. For internal compatibility in V^2 only square terms hold on

$$V^2 \to \alpha^2\Big(\frac{9}{R^2} + \frac{4}{(R-R_0)^2} - \frac{12}{R(R-R_0)}\Big)$$

The solutions search in form

$$f = A + \frac{B}{R} + \frac{D}{R-R_0} + \sum\frac{1}{R-R_n}$$

that leads to algebraic equations for determination of unknown constants, $E,\ A,\ B,\ D,\ R_n,\ R_0$, including R_0 because it is the one of the wave function knots. So the electron correlations are too strong.

Binding energy is

$$\varepsilon = V_0 + m_{ef}\Big[1 - \frac{n_{ef}}{\sqrt{n_{ef}^2 + \alpha^2}}\Big]$$

$$n_{ef} = n + B - l + D$$

where $n = N + l + 1$ is usual main quantum number which begin running, because of extra knot of wave function, from number two, $n = \{2, 3, ..\}$.

The expressions for other coefficients are

$$B_0 = -\frac{1}{2} + \sqrt{\big(l + \frac{1}{2}\big)^2 - a}$$

$$D_0 = \frac{1}{2}\Big[1 - \sqrt{1 - 8b}\Big]$$

$$n_0 = n + B_0 - l + D_0$$

$$B = -\frac{1}{2} + \sqrt{\Big(l + \frac{1}{2}\Big)^2 - 9\alpha^2 - a\Big(1 - \frac{\alpha^2}{2n_0^2}\Big)}$$

$$D = \frac{1}{2} - \frac{1}{2}\sqrt{1 - 16\alpha^2 - 8b\Big(1 - \frac{\alpha^2}{2n_0^2}\Big)}$$

In D-coefficient the solution with minus sign of square root is selected from reason that Rydberg correction must change the main quantum number slowly. In case of small D this choice leads to infinite averaging potential energy. Because the full energy is finite we omit this question. Formal α^2 exactness of these coefficients provide of E/m exactness between α^4 and α^6.

Parameter m_{ef} is the effective mass of electron

$$m_{ef} = m\frac{n_{ef}}{\sqrt{n_{ef}^2 + g\alpha}}$$

$$m = 0.5109523\ MeV;\ \alpha = 0.007297352568;$$

It is external quantity which does not follow from Dirac equation, it was revealed at H and He II spectra fitting that additional mass interaction exists with α^4 strength. Correspondingly, we apply this result to atomic spectra also.

In this way we have three dimensionless parameters, a, b, g, with obscure unknown vacuum energy, V_0. It is possible, and the pilot fit confirm this, that V_0 depends upon quantum numbers. For avoiding this complication the limit of transition energies extrapolated in NIST [7] use at fit of the spectra, namely

$$\varepsilon_{tr} = 5.3917191\ eV - \varepsilon(n, l) + V_0$$

And this is not all. The electron with nonzero orbital momentum intersect the phase boundary while the s-electron is or in gas on in liquid phase without crossing the boundary. From this reason, which was produced by pilot fit, the $l = 0$ states will be regarding separately. In addition to these the states with

maximal orbital momentum are under suspicion because they have no knots of wave function. NIST table contains only few of these states, (2,1; 3,2; 4,3), they are out of consideration.

The values of fitting parameters for $l > 0$ states are

$$a = 0.3083,\ b = 0.62697,\ g = 7.72$$

and for $l = 0$ states

$$a = 0.1421,\ b = -0.1375,\ g = -10.255$$

Negative and positive values of b have simple geometric meaning. In both cases all particles are on one line and two not valence electrons are in one point. If $b > 0$ then the pair of electrons is between nucleus and valence electron, in case $b < 0$ the nucleus is between valence and pair electrons. Experimental and fitted transition energy in eV, the data are from NIST tables [7], are in following table

n,l	calculated	exp
3,0	3.373209	3.373129
3,1	3.834250	3.834258
4,0	4.340903	4.340942
4,1	4.521672	4.521648
4,2	4.540778	4.540720
5,0	4.748581	4.748533
5,1	4.837294	4.837313
5,2	4.847048	4.847153
5,3	4.850979	4.84833
6,0	4.957902	4.957835
6,1	5.007840	5.007826
6,2	5.013473	5.013587
7,0	5.079451	5.07937
7,1	5.110292	5.110300
7,2	5.113834	5.11391
8,0	5.156239	5.15614
8,1	5.176603	5.176542
8,2	5.178973	5.17898
9,0	5.207825	5.20775
9,1	5.221969	5.222000
9,2	5.223632	5.22362
10,0	5.156239	5.15614
10,1	5.254363	5.254346
10,2	5.255746	5.2556

11,0	5.270671	5.2706
11,1	5.278298	5.27790
11,2	5.279208	5.2790
12,1	5.296482	5.296498
12,2	5.297182	5.2972
13,1	5.310619	5.310605
14,1	5.321828	5.321822
15,1	5.330863	5.330764
16,1	5.338254	5.338181
17,1	5.344375	5.344391
18,1	5.349503	5.349541
19,1	5.353840	5.353865
20,1	5.357542	5.357529
21,1	5.390727	5.360724
22,1	5.363486	5.363449
26,1	5.365893	5.365907
27,1	5.372990	5.373028
28,1	5.374306	5.374267
29,1	5.375488	5.375323
30,1	5.376554	5.376417
31,1	5.377518	5.377450
32,1	5.378393	5.378225
33,1	5.379118	5.37904
34,1	5.379917	5.37971
35,1	5.380582	5.38034
36,1	5.381193	5.38098
37,1	5.381755	5.38150
38,1	5.382273	5.38198
39,1	5.382752	5.38245
40,1	5.383195	5.38301
41,1	5.383607	5.37351
42,1	5.383959	5.38399
limit	5.3917291	5.3917191

If the fit to do with natural expression for transition energy

$$\varepsilon_{tr} = \varepsilon(n = 2, l = 0) - \varepsilon(n, l = 0)$$

the result become worse. Why this happens is unclear, because of many

reason for this can be found. Binding energy of ground state is

$$\varepsilon_0 = V_0 + 5.37083\ eV$$

while today measured ionization energy is 5.3917 eV. So a principal situation is possible when the valence electron is in area of continual spectra but the atom is still stable if the temperature of surround medium is enough low. In my opinion this possible effect deserves experimental efforts.

In any case here is good deal of theoretical work. Even students can be involved in job, the flat type of education system is well for some limit.

5 Fluid as mechanical field

5.1 Introduction

Here the word 'fluid' means a continual isotropic homogeneous mechanical medium.

In mechanics, the description of continual states is grounded on Newtonian lows. At this approach from impulse conservation low and phenomenological properties of a system the Navier-Stokes equations are constructed. Such method extends the particle dynamics in area of field objects.

Besides, the fluid regard as a field of mechanical shifts and the lagrangian formalism employ as framework of fluid dynamics, [5] and [6]. The lagrangian formalism is general method for description of any field. However, when this method is taken for description of mechanical continual system then the main property of any field lose of the sight. The property is the spreading of internal interaction in any field from point to point with finite velocity.

Internal mechanical interactions in a fluid are transmitting with velocity of sound. This property is bringing into play if the Lorentz, not Galileo, transformations with parameter c, which is the velocity of sound in fluid, are employed for coordinate system changes. In this article such road is chosen for description of the fluid.

The Clifford algebra, [3][11][12], with standard lagrangian formalism take as tool for delineation the dynamics of fluid. The short review of Clifford algebra properties is in the end of the article. The choice of Clifford's formalism is forced by situation in high energy physics where for description of fermions the space-time assumed, however implicitly, to be the Clifford algebra but for description of the bosons the space-time is taken as vector variety. This is hard for comprehension. Because the algebra contain the vector space it seems more consistently put into use the Clifford algebra anywhere, including the mechanical systems.

For going in this way the some mixture of Euler and Lagrange variables is convenient. If in point $\vec{x}$ at time t is the particle, which at time t_0 was in point $\vec{x}_0$, then three-vector of mechanical shift $\vec{\xi}(t,\vec{x}) = \vec{x} - \vec{x}_0(t,\vec{x})$ together with quantity $\xi_0 = c(t - t_0(t,\vec{x}))$ regard as the space and time parts of the shift four vector $\xi(x)$

More detailing this looks as

$$\xi = \xi_0\gamma_0 + \xi_n\gamma_n$$

$$x = x_0\gamma_0 + x_n\gamma_n$$

$$x\gamma_0 = x_0 + \vec{x}$$

$$\xi\gamma_0 = \xi_0 + \vec{\xi}$$

When absolute time is taking - this is usual representation for mechanical systems because the fundamental interactions are transmitting with velocity of light - then the time is independent upon the space points and time's part of the shift four vector becomes known (taking for simplicity $t_0 = 0$)

$$\xi_0 = ct$$

The space variety also becomes absolute in this case. Due to existence of fundamental interactions the relative velocities in fluid may exceed the velocity of sound. Of course, they always are less of light velocity.

5.2 Fluid parameters

It is well approach regard any mechanical system as variety of particles. The interaction between particles is so small that the ones are on mass shell and each particle move on trajectory $x(s)$. The tangent four vector, $u(s)$, to trajectory of the particle which has the mass M and four impulse P is

$$P = Mu$$

$$u = \frac{dx}{ds}$$

$$u\gamma_0 = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}(1+\frac{\vec{v}}{c})$$

For continual state it needs to put $M = \rho d^3x$ where ρ is the density of the mass and d^3x is small volume. Then two independent parameters exist. These are the four scalar $m = \rho\sqrt{1-v^2/c^2}$ and the four vector of the mass flow J_m

$$J_m\gamma_0 = \rho(1+\frac{\vec{v}}{c})$$

In mechanical interactions the mass is conserving quantity so

$$\partial_t\rho + \overrightarrow{\nabla}\cdot(\rho\vec{v}) = 0$$

Other set of parameters is the relative shifts (these are the deformations), which in local limit are following

$$\nabla\xi = s + f$$

$$s = \nabla\cdot\xi = \partial_0\xi_0 + \overrightarrow{\nabla}\cdot\vec{\xi}$$

$$f = \nabla\wedge\xi = -\partial_0\vec{\xi} - \overrightarrow{\nabla}\xi_0 + i_c\overrightarrow{\nabla}\times\vec{\xi}$$

where $c\partial_0 = \partial_t$ and all matrices are four-dimensional.

In case of absolute time the deformations are following

$$s = 1 + \overrightarrow{\nabla}\cdot\vec{\xi}$$

$$f = -\frac{\vec{v}}{c} + i_c\vec{h}$$

$$\vec{h} = \overrightarrow{\nabla}\times\vec{\xi}$$

where $\vec{v}$ is the local velocity of fluid, all matrices are four-dimensional.

If not relativistic formalism is using then

$$\overrightarrow{\nabla}\vec{\xi} = \overrightarrow{\nabla}\cdot\vec{\xi} + i\vec{h}$$

where all matrices are two-dimensional. Hence the appearance of the pseudovector $\vec{h} = \overrightarrow{\nabla}\times\vec{\xi}$ as a part of deformations is inevitable in field model of

a fluid. As standard in usual model of fluid the variable $\overrightarrow{\nabla} \times \vec{v}$ is taking for one of parameters.

The deformations are field quantities. They are pure mathematical but not physical objects. In other words, these parameters do not exist in nature. It is because $m\xi$ but not ξ itself may exists as real quantity. We get out these variables with goal to make the construction of fluid lagrangian more evident.

Remark, the coincidence of parameter $\vec{v}$ for both $\nabla\xi$ and u fields permit do not count the shadow w-field separately.

The speed of fundamental interactions spreading is equal to velocity of light. Hence the snapshot of stream can be done and the picture of current lines will be appearing. On a line of current the interval is space-like and so the tangent three-vector for a line is unite pseudovector $i\vec{v}/v$. For simplicity below the existence of such additional parameter is ignored. Remark that in work of a soviet physics near 1972 year a unit vector was introduced as an external parameter for description of solid state.

5.3 Lagrangian of the fluid

The lagrangian of a single field can be written as sum of the free field lagrangian and the self-interaction lagrangian

$$L = L_0 + L_{sint}$$

Here L_0 is the lagrangian of free field. This means that external and self-interaction forces are switching off. The lagrangian of free fundamental field is the square form of field tensions (if the ones disappear on infinity)

$$L_0 = kF^2$$

$$k = \ constant$$

For fluid the condition of internal forces decreasing when the distances increase is valid. From Hook low the fluid tensions are linear functions from deformations. However, in fluid the parameter k is not constant. Indeed, this parameter has the dimension of energy density. Because self-interaction is switching out only the quantity $mc^2 = c^2\rho\sqrt{1 - v^2/c^2}$ has required dimension. And from Bohr correspondence principle - this is the one of general physical principles - it needs to take $k \sim c^2\rho$. Hence for fluid the lagrangian of free field (in Hook's low area) is following

$$L_0 = \frac{1}{2}mc^2\overline{\nabla(s+f)}\nabla(s+f) = \frac{1}{2}mc^2(s^2 - f^2)$$

$$\nabla = \frac{1}{c}\gamma_0\partial_t - \gamma_n\partial_n; \quad \nabla\gamma_0 = \frac{1}{c}\partial_t - \overrightarrow{\nabla}$$

Not mechanical interaction created the mass of fluid so, because of Lorentz invariance, the quantity m is external parameter. Also $m\xi$ is entire quantity and, foregoing, the fluid motion is independent upon the shifts directly. From these reasons m is not variable by shift four vector and so m is considering as a function of space-time point, $m = m(x)$, not as function of deformations, $m \neq m(\xi)$. This simplification is the example of coherence condition usage. Correspondingly, the four dimensional equation for ideal fluid is

$$\nabla\left[mc^2(s+f)\right] = 0$$

Because the parameters $s,\ f$ are taken with equal coefficients the compression modulus is equal to $1/(c^2\rho)$, this is not in bad agreement with data and so acceptable for first approach.

In any case the self-interaction lagrangian can be written as

$$L_{sint} = \xi \cdot J$$

where four vector J is not variable quantity. By physical meaning this four vector represent the self-interaction forces in fluid. As norm for fluid the ones do not depend directly upon shifts and so $J \sim J_m$. From physical reasons these forces disappear when $f \to 0$ even if the pressure is not equal to zero. Correspondingly,

$$J \sim fJ_m$$

or, more widely,

$$J = af \cdot J_m + bf \wedge J_m$$

In this way the equation of fluid dynamics in four dimension form is

$$\nabla\left[mc^2(s+f)\right] = af \cdot J_m + bf \wedge J_m$$

Unknown scalar functions $a,\ b$ depend on the deformations and have the dimension of acceleration. Below for simplicity it is assuming that these functions are equal to constants. As with the compression modulus it is possible to take, as more symmetrical for first approach, $b = -a$

Two essential differences with standard approach are here.

In any field theory both the time and the space derivatives appear symmetrically, in usual model of a fluid the degree of the ones differ.

The parameter $k = mc^2$ is not constant and so the pseudo-four-vector part of field equation in general case is not zero as it is must be for fundamental

fields. For example and comparison, the lagrangian of free electromagnetic field contains the pseudoscalar term $\vec{E} \cdot \vec{H}$. It has no matter is $\vec{E} \cdot \vec{H}$ equal to zero or not, this part of lagrangian create the pseudo-four-vector dynamical equation. However, the one coincide with kinematic restrictions $\overrightarrow{\nabla} \cdot \vec{H} = 0$, $\partial_t \vec{H} + \overrightarrow{\nabla} \times \vec{E} = 0$. For fluid, because of $m = m(x)$, the kinematic and the dynamical pseudo-four-vector equations do not coincide. In a field models the invariance of lagrangian at time and space inversions are jointed so the whole pseudovector part of the lagrangian may be equal to zero what bring some kinematic restrictions for shifts.

5.4 Equations of the stream

For going to three-dimension equations of motion it needs to take the absolute time, then multiply the basic equation on matrix γ_0 and put together the terms with equal O3 properties. It is conveniently denominate

$$p_c = -c^2 m(1 + \overrightarrow{\nabla} \cdot \vec{\xi}) = (p - c^2\rho)\sqrt{1 - \frac{v^2}{c^2}}$$

where the note of hydrostatic pressure, p, is clear. In result the equations of stream have following form

$$\partial_t p_c + c^2 \overrightarrow{\nabla} \cdot (m\vec{v}) = \frac{a}{c}\rho v^2$$

$$\partial_t (m\vec{v}) + \overrightarrow{\nabla} p_c + c^2 \overrightarrow{\nabla} \times (m\vec{h}) = -\frac{a}{c}\rho(\vec{v} + \vec{h} \times \vec{v})$$

$$\overrightarrow{\nabla} \cdot (m\vec{h}) = -\frac{b}{c^3}\rho\vec{v} \cdot \vec{h}$$

$$\partial_t (m\vec{h}) - \overrightarrow{\nabla} \times (m\vec{v}) = \frac{b}{c}\rho\vec{h}$$

$$m = \rho\sqrt{1 - \frac{v^2}{c^2}}$$

Below the velocity of sound take for unit of speed. From Le Chatelier principle the constant a is positive and the constant b is negative numbers. Usual boundary conditions are valid with one supplement. Because any mass move

with finite speed the singular solutions for velocity must be rejected. For example, if the axial symmetrical stream has singularity $v = q\, ln(\sqrt{x^2 + y^2})$ with q=constant then self-energy of this state is finite but because at small distances the velocity growth to infinity we must put q=0.

The elimination of unusual parameter $\vec{h}$ from equations of stream is possible. Using both kinematic

$$\overrightarrow{\nabla} \cdot \vec{h} = 0; \quad \partial_t \vec{h} - \overrightarrow{\nabla} \times \vec{v} = 0;$$

and dynamical pseudoscalar and pseudovector equations, we get the following connection between $\vec{h}$ and the usual variables of fluid dynamics

$$\vec{h}(b\rho - \partial_t m) = \vec{v} \times \overrightarrow{\nabla} m$$

Consequently, the vicinities of points

$$\partial_t \left(\rho\sqrt{1 - v^2}\right) = b\rho$$

regularly are the regions of unstable flow.

After the pseudovector $\vec{h}$ excluding the equation system contains only usual quantities and is closed. However, reduced system is closed only formally, in general case the compatibility of its solutions with kinematic restrictions for pseudovector $\vec{h}$ needs to check. Or another restriction for extra equations elimination brings into being.

Other essential difference with usual model is that in general case a stream is not continual. When velocity of stream reach the value of the sound velocity then the phase of quantity m is changing

$$\rho\sqrt{1 - v^2} \to i\rho\sqrt{v^2 - 1}$$

and we are going in area which is space-like for mechanical but time-like for fundamental interactions. For example, the three-vector equation in space-like area is

$$\partial_t(m\vec{h}) - \overrightarrow{\nabla} \times (m\vec{v}) = -a\rho(\vec{v} + \vec{h} \times \vec{v})$$

Both intuitively and formally, this is abeyance area because here is the solution $f = 0$ which is trivial for usual zone but unexpected for space-like area.

The mass conservation low is valid anywhere if the relative velocities in stream are less essentially of light velocity. Remark once again, the density of mass is external parameter.

Because here the sound velocity always is the constant it is somewhat unusual thermodynamic situation, nevertheless, it is real in many cases. Not

thermodynamic but field approach was using, however, the scalar equation after integration gives the thermodynamic connection.

The $m\xi$, not ξ itself, exist in nature so initially the $m\xi$ needs take as potential of mechanical field. Nevertheless, because of mass conservation low, it is possible the dividing of the mass from other variables.

Of course, this is the simplest field model of fluid.

For example regard few streams. Only the short equation system, because of its formal fullness, is using.

5.5 Ideal fluid

In this case all internal interactions ignored and the equations for extended pressure p_c and impulse $m\vec{v}$ are isolated wave equations

$$(\partial_t^2 - \Delta)p_c = 0$$

$$(\partial_t^2 - \Delta)m\vec{v} = 0$$

Elementary motion is the stationary stream of uncompressed fluid restricted by two sheets with gap $x = [0, L]$. For geometry

$$\vec{v} = v(x)\vec{e}_z$$

and with boundary conditions $v(0) = 0;\ v(x_1) = v_1$ the velocity of stream is

$$v^2 = \frac{c^2}{2}\left(1 - \sqrt{1 - k^2x^2}\right)$$

Such flow is possible if the integration constant k is small, $kL < 1$. Moreover, the stream becomes unstable if the velocity v_1 is big enough. Indeed, if the forces are absent the motion of a particle on straight line is going with zero acceleration, the similar motion of ideal fluid take place with zero gradient of pressure along the velocity direction. Then the pressure in this flow has no the explicit dependence on space point, it is

$$p = c^2\rho + q\frac{c^2\rho}{\sqrt{1 - v^2/c^2}}$$

where, because from data in any fluid $p < c^2\rho$, the integration constant q is less of zero. (The discrepancy with Bernoulli low is caused by simple expression for compression modulus). Correspondingly, for big velocities the pressure becomes negative that means the instability of flow. These properties of simplest stream are similar to the ones of the plane Couette flow, however the last is being for not ideal fluid.

For pipe stream the situation is similar so sometimes the coaxial but not simple tubing will be best for a fluid moving.

In case of the stream with geometry

$$\vec{v} = v(x_\perp)\vec{e}_\varphi; \quad \vec{x}_\perp \cdot \vec{e}_\varphi = 0$$

which stands, for example, to different rotations in atmosphere, the solutions are:

or

$$v = 0,$$

or

$$v\sqrt{1-v^2} = Ax_\perp + \frac{B}{x_\perp}$$

Correspondingly, in general case as the cyclones as the anticyclones are concentrated, due to constrain $v < c$, in the some finite areas, out of the ones the fluid is or immovable or there is the whirl in whirl structure of flow.

Ideal fluid is the first face of the any. At least qualitatively, the consideration of this system reveals the main features of real fluids. So it is possible to expect the emergence as h, they are created by accelerations, as v, they become due to interaction spreading finiteness, singularities in the streams. Because $f = -\vec{v} + i\vec{h}$ it is questionably that the approximation of $a,\ b$ functions by means of constants is valid for unstable stream.

In Newtonian mechanics any interaction spread with infinite velocity and it is well approach if the relative speed of the particles is more less of light velocity. But in fluid dynamics certainly it needs take into account the field conception on point to point spreading of the mechanical interaction with velocity of sound. This may be make up using the field theory tools as it is done in this article, or using the methods of relativistic mechanics, or by other way, but this needs doing.

6 Potentials of pionic field

6.1 Extended Yukawa potential

Here the classical potential of pionic field is constructed using the usual lagrangian formalism.

In a nucleus the nucleons are near mass shell. Then in low energy area it is possible to regard the nucleon as moving in potential well which is generated by cloud of virtual particles. The pions give the main contribution to

interaction of a nucleon with cloud of virtual mesons. Correspondingly, the pionic field is the main part of strong interaction in nuclei. Simplest potential of pionic field is the Yukawa potential

$$p(R) \sim \frac{1}{R} exp(-mR)$$

where m is the mass of free pion.

Both from experiment and from theory this potential is not valid on small distances. From data the nuclear forces do not grow in center of field. In theory the self-energy of any field must be finite. Correspondingly, at phenomenological description of the nucleus not Yukawa but phenomenological potentials of Woods-Saxon, or Bonn-Paris, or other types are using.

An extension of Yukawa potential to area of small distances is desirable. This is possible to do just as it was made in previous section with potential of electromagnetic field.

The first step is the regarding of virtual particles cloud in a nucleus as a continual state. Then in general case the additional parameter, $u(x)$, exists, by physical meaning it is the local four velocity of virtual medium. The pion in cloud is far off mass shall and for moving a pion in free space it needs to spend the energy no less of mc^2. Therefore, for pionic cloud $u^2 < 0$. Of course, this condition can be valid in many other cases. This cloud of virtual pions form the pionic field in nucleus. Pionic field have two local parameters, the potential and four velocity, which both are essential for description of the field.

The next step is the consideration of four velocity itself as potential of some field, w-field, which was introduced in subsection 'Foundation'. The virtual inertial forces of w-field will prevent tightening of pionic cloud and nucleus in a point with infinite self-energy.

For quantitative description of virtual pionic cloud in classical physics it is need to build the lagrangian of field. On this stage the main builder's requirements is: independently of the nature of a field the 'jet', it is the quantity

$$j = \delta L_{int}/\delta\varphi,$$

must be the linear function of four velocity. The pion is pseudoscalar isovector particle and so the pionic field has these properties. Simplest lagrangian of pionic field with its shadow w-field take as following (always using Clifford algebra, [3][11][12])

$$L \sim \frac{1}{2}(\nabla p)^2 + \frac{k^2}{2}(\nabla u)^2 + \frac{g_1}{2}p^2 + g_2 p(u \cdot \nabla)p$$

$$\nabla = \gamma_0 \partial_0 - \gamma_n \partial_n$$

Where the first and second terms are the lagrangians of free pionic and free w-fields. Today for usual interactions the square form of the ones is almost axiom.

Third term is simplest self-interaction lagrangian for pionic field. It is widely known and used. However, as it was seeing in example of Coulomb field, it is possible that on infinity the potential of pionic field is not equal to zero.

Last term is simplest lagrangian for interaction between pionic and w-field. Such form of the one is possible because, being the term of lagrangian, the quantity $\nabla \cdot (up^2)$ effectively is equal to zero. Remark that we neglect by possible term in lagrangian $\sim u^2$ because the self-interaction of w-field, at least in area of small energies, looks too exotic.

The variation of the lagrangian is following

$$\begin{aligned}\delta L \sim &(\nabla p)(\nabla \delta p) + k^2 (\nabla u)(\nabla \delta u) + g_1 p \delta p + \\ &+ g_2 \delta p (u \cdot \nabla) p + g_2 p (\delta u \cdot \nabla) p + g_2 p (u \cdot \nabla) \delta p\end{aligned}$$

Using the standard way of variation formalism we get the field equations in form

$$\nabla^2 p = g_1 p - g_2 p \nabla \cdot u$$

$$k^2 \nabla^2 u = \frac{g_2}{2} \nabla p^2$$

For static spherical symmetrical field

$$p = p(R), \; u\gamma_0 = u(R)\vec{e}_R$$

and after velocity parameter excluding the equation for pionic potential is

$$p'' + \frac{2}{R} p' = -g_1 p + c_1 p^3$$

With boundary condition $p(0) = 0$ the equation in area of small distances has no analytical solutions and we reject this equation.

Due to coherence condition here exist other solutions of variation task. The solution similar to Glauber state is following (for velocity the equation is without changing)

$$\nabla^2 p = g_1 p + g_2 (u \cdot \nabla) p$$

with restriction on interaction constants in form (coherence condition)

$$\int p(u\cdot\nabla)\delta p d^4x = 0$$

where all function after interaction sign are the solutions of upper system of differential equations. So

$$\delta p = \frac{\partial p}{\partial c_n}\delta c_n$$

where c_n are the constants of integration. If the ones are fixed numbers ('charges') then coherence condition is automatically fulfill. For simplicity below this type of coherence condition is using.

In this case the equations for static spherical symmetrical field are following

$$p'' + \frac{2}{R}p' = -g_1 p - g_2 u p'$$

$$u' + \frac{2}{R}u = cp^2$$

In lower equation we take into account that the self-energy of any field is finite and for simplicity the pionic potential is chosen vanishing on infinity. After the velocity parameter excluding the equation for pionic potential become following

$$p'' + \frac{2}{R}p' = -g_1 p + \frac{p'}{R^2}\Big(s_1 + s_2\int_0^R (p^2 - p_\infty^2)R^2 dR\Big)$$

Now the linear equation has physical solution at small distances. From physical reason at approximate searching of pionic potential it is natural the usage of free field potential as first input. For free pionic field the potential is

$$p_f = k_1 + \frac{k_2}{R}$$

Once again, the self-energy of any field must be finite so the last integration constant take equal to zero.

In this way the approximate equation for potential of pionic field is following

$$p'' + \frac{2}{R}p' = -g_1 p + p'(\frac{c_1}{R^2} + c_2 R)$$

with solution

$$p \sim exp(-\frac{a}{R} + \frac{g_1}{6}R^2)$$

At first look the constant g_1 determine the behavior of potential on infinity, at small distances the constant a, which is the scale of free w-field, set up

the activity of potential. This is the potential well but it is imaginary well because the pionic field is pseudoscalar field. It is simply visible when the Clifford algebra [12] is using. In this case the coordinate vectors are the Pauli matrices. In space algebra the matrix

$$\vec{e}_1\vec{e}_2\vec{e}_3 = i1$$

change sign at parity transformation. Hence the imaginary unit of the complex numbers algebra at that time can be considered as the pseudoscalar of space algebra.

Remark that in space-time Clifford algebra the two pseudoscalars exist (or two different imaginary units if we wish). Then in general case the pionic potential is the mixture of usual $\sim i$ and chiral $\sim i_c$ pseudoscalars.

This extended Yukawa potential may be useful in area of low energy nuclear physics.

6.2 Shell model for mirror light nuclei

For all days of nuclear physics the structure of nuclei is the interesting question [19], for light nuclei the last theoretical results are in [20] and [21]. The base of usual models is: the nucleon-nucleon potential, which gets fitting the NN scattering data; the solution of many-body Schrodinger equation. In this section both these essences are rounded applying the extensions of Yukawa and Coulomb potentials together with the potential of vacuum gluonic field.

Let us regard the simplest shell model (the point-like nucleon move in classical field) using nonlinear potentials.

Following fields, in order of their assumed weights, act in nucleus: pionic, gluonic, electrostatic and w-field.

The w-field was taken in the space-like form, $u(x)^2 < 0$, and in vacuum state so this field does not interact with electrostatic and gluonic fields because the ones are time-like fields, $A(x)^2 > 0, G(x)^2 > 0$. The function of w-field is the modification of pionic potential. It is possible that the w-field act directly on nucleon, the example of such interaction is in subsection 4.6, for first approach this effect is missing. Because in general case all components of a four vector are presented such decoupling of fields is valid as first approach only.

Consequently, the electrostatic field is in free state and the potential energy of a proton in this field is

$$V_c = \alpha\frac{Z-1}{2R}$$

This potential in area of small distances is not physical but, because of asymptotic boundary conditions usage, this has no matter.

Similarly, gluonic field is in free state (more details about this field are in section 7) with potential

$$\varphi_g = c_1 + c_2 R$$

For in-nucleus interaction between the nucleons we put the charge of gluonic field equal to zero, $c_2 = 0$. Therefore, the respective contribution of gluonic field in binding energy is constant and the potentials of vacuum, for gluonic field the constant c_1, are observable numbers. The lagrangian of gluonic field is not quadratic form hence the superposition principle is not valid for this field. For first approach the corresponding addition to binding energy of the nucleon take almost identical for all light nuclei.

Among acting on the nucleon in nucleus forces the pionic ones are biggest. All new features of extended pionic potential are generating by free w-field. From this reason let us switch off the self-interaction of pionic field and put $g_1 = 0$. This does not mean that the mass of a pion is zero because in this model any particle is not local field object which has not zero size and so the mass of a particle is the integral from tensions and potentials of fields. Switching off the pure self-interaction of pionic field contradict to common approach but it has hard physical ground because the pure field self-interaction and third Newtonian low (the impulse conservation low) are not in harmony. In this case for pionic potential the exact vacuum solutions exist

$$p \equiv constant,\ R^2 u \equiv constant$$

and in low energy area the not constant part of pionic potential can be regarded as small perturbation of vacuum potential. On whole R-axis that always will be true. Pionic potential is considered as pure chiral pseudoscalar, for simplicity it is restricted by condition $p(0) = 0$. After these simplifications the potential of pionic field is

$$p = i_c\, \vec{\tau} g\, exp(-\frac{a}{R})$$

More than hundred years ago was recognized that a particle does not interact with other particles in a system but interact with the fields. Therefore, the pionic field is possible to regard as external field. On big distances the behavior of pionic potential is similar to Coulomb field. On small distances the potential quickly disappears. This means that pionic forces act only on the nucleons which are near surface $R = a$. In other words, these are the surfacing forces. Are these forces of finite or long range as well as contain they

repulsive forces or not is the matter of a convention. The parameters of pionic field depend upon the neutron and proton numbers in nucleus. For simplicity below mirror nuclei are considering, they contain equal number of protons and neutrons. For mirror nucleus the electric charge, Z, and the number of nucleons, A, are connecting as $2Z = A$. In this case the simplest approach for surfacing forces is

$$a \sim (A-1)^{2/3}$$

with may be additional slow dependence on mass number. Let us hold of the simplest kinematic multiplier and put

$$Ga = k\frac{(A-1)}{A}(A-1)^{2/3} \qquad k = constant$$

By physical meaning the parameter Ga is the dimensionless charge of pionic field. In this way we take into account the essential properties of pionic field generated by free w-field and avoid the face of many-body problem.

For both the proton and neutron the space-time dependence of wave functions is identical if the electromagnetic interaction eliminate.

The Dirac equation initially was grounded on Clifford algebra and for inclusion of interaction between the fermion and a field which has any algebraic structure the problems did not appear. The equation for wave function of nucleon in pionic field is following

$$(i\nabla - i_c V)\Psi = M\Psi$$

$$V = Gexp(-\frac{a}{R})$$

$$2Z = A, \hbar = 1, c = 1$$

For stationary states with energy E the equation for upper part of wave function is

$$(\Delta + V'\vec{e}_R)\Psi_{up} = (M^2 - E^2 + V^2)\Psi_{up}$$

Obviously, this wave function is not simple factorizing term, it is the sum of two terms with different algebraic structure and differential equations for radial parts of wave function have forth order. By physical meaning the term $V'\vec{e}_R$ represent the spin-orbital interaction and from data the one may be discarded for light nuclei.

After discarding by spin-orbital interaction and including the gluonic and electrostatic forces the Dirac equation for logarithmic derivative of nucleon radial wave function is

$$f' + f^2 + \frac{2}{R}f = \frac{l(l+1)}{R^2} + M^2 - (E - V_g)^2 + 2MV_c + V_p^2$$

where: $M = 938\,MeV$ and E is the energy of nucleon in nucleus; V_g, V_c, V_p are the potential energies of nucleon in vacuum gluonic, electrostatic and pionic fields of nucleus.

For free motion of nucleon its energy is: in empty space $E_{free} = M$, while in pionic field, running the constant a to zero, $E_{free}^2 = M^2 + G^2$. Correspondingly, the binding energy of a nucleon in this field determinate as

$$\varepsilon = \sqrt{M^2 + G^2} - E,\ \varepsilon > 0$$

Nuclear physics has some problems with description of electrostatic interaction. We have no doubts that instability of heavy nuclei is produced by electromagnetic interaction between protons. If for description of this interaction the Coulomb potential, $V_c = \alpha(Z-1)/R$, is selected then the area of stable nuclei is far beyond of Mendeleev table. Because this property holds in all models the some modifications of electrostatic potential needs. Typically the potential of charged sphere regard as suitable for heavy nuclei. In nonlinear model the situation with Coulombian interaction is almost the same. Because the extended Yukawa potential quickly disappears on small distances the motion of nucleons in internal area of pionic field is almost the free motion. Correspondingly, the electrostatic interaction gathers the protons near a surface, $R = R_0$. Probing particle, it is a proton itself, being in internal area of pionic field does not feel the electric charge. The difference with usual model is that this property holds for any mirror nuclei. We will treat this circumstance as strong polarizability of pionic field; in this case the main part of electrostatic field is suppressed in all area of pionic field that is the whole nucleus. For description of this property the nonlinear electrostatic potential decompose in $1/(R - R_0)$ series (as if it has been the plasma) and hold two main terms. Namely,

$$V_c = c_1\alpha\frac{(Z-1)}{R - R_0} - c_2\frac{a(Z-1)}{(R - R_0)^2}$$

where $0 < c_1 \ll 1$ and $c_2 > 0$ are unknown constants.

Because R_0 is the one of wave function knots the asymptotic procedure for equation solving will involve the additional equation so we prefer to use the

usual approach. For this reason below the pionic potential approximate as

$$V_p^2 = G^2\big(1 - 2\frac{a}{R} + 2\frac{a^2}{R^2}\big)$$

and so the corrections to energies of states with knots of wave function $N \neq 0$ are missing.

For vacuum potential of gluonic field the independence upon mass number was assumed. However, because the deuteron is special case we take

$$V_g = -2d\frac{(A-1)}{A}$$

where d is unknown constant.

Renominating the some constants (because A is the mass number) the wave function take as

$$f = B + \frac{D}{R} + \frac{K}{R-R_0} + \sum \frac{1}{R-R_n}$$

$$\Psi \sim R^D(R-R_0)^K \prod (R-R_n) exp(BR)$$

As result the energy of a proton (for neutron needs to put or $K = 0$ or $Z = 1$) in a nucleus is

$$\varepsilon = -2d\frac{(A-1)}{A} - m_{ef}\Big[1 - \sqrt{1 - G^4a^2/(m_{ef}n_{ef})^2}\,\Big]$$

$$m_{ef} = \sqrt{M^2 + G^2}$$

$$n_{ef} = D + N + 1 + K$$

$$D = -0.5 + \sqrt{(l+0.5)^2 + 2G^2a^2}$$

$$K = 0.5\Big[1 - \sqrt{1 - 0.0035(Z-1)Ga}\,\Big]$$

where N is the number of wave function zeros. To avoid the searching of nonworking constants and because of in-nuclei quantities we are interesting for, the constant $c_1 \to 0$, however, hold c_2. Taking into account that the last known mirror nucleus is 80Zr the value 0.0035 was found by manual. It has small influence on the value of basic unknown parameters, nonlinear part of electrostatic interaction is holding because it is interesting that not

main part of electrostatic potential produce the instability of nuclei and this is compatible with T-invariance.

The expression for nucleon energy regard as exact, because the nuclei structure is unknown not the minimization procedure but the three points for calibration of unknown constants are choosing. The ones are: the binding energies of the deuteron, [2.224], and alpha particle, [28.284] with condition, because of absence as excitations as resonances in deuteron, that gluonic field subtraction is exactly equal to binding energy of nucleon in p=1, n=1 pionic field for (0,1) state.

This calibration gives following values of unknown parameters:

$$G = 302.316\, MeV;\ k = 0.3908,\ d = 0.4317\ MeV;$$

For simplicity, the mirror nuclei regard as being built up from virtual alpha particles and deuterons. Correspondingly, the energies of pn pair are calculated only.

Below all energies are in MeV; calculating quantities are in blue while measured in black color, sometimes the last are in square brackets also. The data was taken from [8].

As in any model with spherical symmetrical potential without spin-orbital interaction the nucleon energy depends upon number of wave function zeros, N, and orbital momentum, l. The states may be numerated as (N, l). It is quit noticeable that changing of zeros number create bigger shift of levels than changing of orbital momentum. This means that quantity N but not N+l+constant is preferable as main quantum number of levels what create some troubles with choice of shells order. Along (N,l) numbers the typical hierarchy of levels is following: (0,0); (0,1), (1,0); (0,2), (1,1), (2,0); (0,3), (1,2), (2,1), (3,0); etc.

Additionally, let us pair off the nuclei:

$$^{2}H,^{4}He;\ \ ^{6}Li,^{8}Be;\ \ ^{10}B,^{12}C;\ \ ^{14}N,^{16}O;\ \ etc$$

In any pair the first nucleus has unpaired nucleons. From data at passing from last nucleus in pair to first nucleus in next pair the binding energy per nucleon downfall. In any shell model this means that the new shell or subshell is opening at going from pair to pair. Or may be the change of subshell filling does occur.

Spin-orbital interaction is discarded; however, for qualitative estimations the brief consideration of its properties needs.

6.2.1 Spin-orbital interaction in pionic field

Using Clifford algebra it is convenient a three-dimensional equation for particle of half one spin multiply from left on conjugated spinor and so work with matrices. For angle part of wave function there are two independent matrix-solutions [3] with opposite parities, $\vec{e}_R S(\theta,\varphi)$ and $S(\theta,\varphi)$, they are connected by angle part of gradient operator

$$\vec{\nabla} = \vec{e}_R\partial_R + \frac{T}{R}$$

as

$$T\vec{e}_R S = \gamma S;\;\; TS = (2-\gamma)\vec{e}_R S$$

where the coefficient $\gamma = \{-l,\ l+1\}$ for $j = \{l+1/2,\ l-1/2\}$. Hence with switched off spin-orbital interaction the states are parity mixed.

In tree-dimension form of Dirac equation the term, which was neglected,

$$\vec{e}_R V'_P = \vec{e}_R \frac{a}{R^2} exp\big(-\frac{a}{R}\big)$$

presents the spin-orbital interaction in pionic field. At least for not heavy nuclei this term can be calculated as small perturbation. This makes clear that the spin-orbital splitting in pionic field slowly depends on the quantum numbers and growth along of mirror nuclei line. Correspondingly, the states with alpha particles are not splitting while a state with not zero orbital momentum is splitting if it contains the deuteron. Because the proton and neutron in pionic field of mirror nucleus are identical particles they have, being jointed in deuteron, the same spin states and so the single virtual deuteron has two possible spin states. The deuteron in ground state of mirror nucleus occupied the lower position. However, in external electromagnetic field it can be located on upper state of spin doublet. The necessity of careful investigation of this circumstance is obvious because the possibility of electromagnetic energy accumulation by nuclei appears.

Here we are interesting in more strong electromagnetic transitions and in some cases, because of existence another reasons for nearness of the lines, will treat the nearness of two lines as spin-orbital splitting.

6.2.2 Binding energies and spectra

$4He$

Binding energies of pn pair in alpha particle are following

state	energy	range
0,0	14.143	-
0,1	5.642	-
1,0	4.235	-
0,2	2.188	-
1,1	2.006	-
2,0	1.521	-
3av	0.622	-0.13,+0.22
4av	0.020	-0.015,+0.18
3,1	-0.031	-
4,0	-0.158	-

In fourth shell the averaging was made for states with positive energy. Beginning from this shell, because of gluonic subtraction from energy of the nucleon, the states with negative energies appear, namely (3,1), (4,0) and all following states. The cases when each pn pair has negative binding energy are treated as resonances. Because the resonances are placed closely the energies of first fourth of them are calculated.

Minimal observable excitation has 20.21 value and so all nucleons of this nucleus are excited at once. When all nucleons are on the same shell the excitation energies and their assumed connection with data, the ones are in square brackets, are

$$4(0,1) = 17.00\ [absent]$$

$$4(1,0) = 19.82\ [20.21]$$

$$4(0,2) = 23.91\ [23.64]$$

$$4(1,1) = 24.27\ [24.25]$$

$$4(2,0) = 25.24\ [25.21]$$

$$4(3av) = 27.04\ [27.42]$$

$$4(4av) = 28.28\ [absent]$$

$$4(3,1) = 28.35\ [28.37]$$

$$4(4,0) = 28.60 \text{ [28.64]}$$

When in (0,1) state is a single pn pair while the second pair is on upper state then only one transition,

$$2(0,1+2,0) = 21.12 \text{ [21.01]},$$

is in correspondence with data. This means at least the partial forbidding of (0,1) state for excitations.

Between other crossed transitions the acceptable are;

$$2(1,0+0,2) = 21.86 \text{ [21.84]}$$

$$2(1,0+3av) = 23.43 \text{ [23.33]}$$

$$2(1,1+3av) = 25.66 \text{ [25.95]}$$

$$2(4av+3,1) = 28.32 \text{ [28.31]}$$

$$2(4av+4,0) = 28.44 \text{ [28.39]}$$

This is acceptable result. The possible forbidding of (0,1) state and the extra possible transitions are the questions. Because of Coulomb-like type of the spectra, the number of extra transitions will be grown at moving along A-line. So some restrictions of the possibilities are necessary. Remark, the non-linearity of electrostatic potential has no direct influence on the energies of alpha particle but not direct it has. The comparisons with usual models failed because in arxiv.org a calculation of 4He spectrum was not found.

$6Li$

Binding energies of pn pairs in 6Li are following

state	energy	range
0,0	21.094	-
0,1	11.883	-
1,0	8.330	-
0,2	6.111	-
1,1	5.371	-
2,0	3.992	-
3av	2.74	-0.5,+0.7
4av	1.41	-0.2,+0.5
5av	0.624	-0.1,+0.3
6av	0.184	-0.03,+0.1
6,0	-0.105	-

In sixth shell the unstable states appear and on this shell the table of energies is interrupted because for today the resonances of this nucleus were not observable. For such levels the structure of the nucleus is: the lower, (0,0), shell is empty, two pn pairs are in (0,1) state and the one pn pair is in (1,0) state. Binding energy of this configuration is

$$4(0,1) + 2(1,0) = 32.1 \text{ [32.0]}$$

For external transitions, out of (1,0) state, let us assume that virtual alpha particle in (0,1) state is excited as whole. In this case the half empty s-state forbid all transitions of two pn pairs from (0,1) state without excitation of (1,0) state. This restriction eliminates the excitations of two pairs and permits the single and triple pair transitions from ground state to uppers, namely

destination states	calculated energies	observable energy
one pair transitions		
2(1,0-0,2)	2.219	2.186
2(0,1-1,0)	3.553	3.562
2(1,0-2,0)	4.338	4.312
2(1,0-3av)	5.59	5.366 5.65
three pair transitions		
4(0,1-1,1)+2(1,0-1,1)	15.98	15.8
4(0,1-2,0)+2(1,0-0,2)	18.00	17.958
4(0,1-3av)+2(1,0-0,2)	20.5	21.5
4(0,1-3av)+2(1,0-3av)	23.9	23.2
4(0,1-3av)+2(1,0-4av)	25.2	24.779 24.890
4(0,1-4av)+2(1,0-4av)	27.8	26.59
4(0,1-6av)+2(1,0-6av)	31.5	31

However, the things did not have to be so simple as the table shown. By physical meaning the second transition, (0,1)-(1,0), can be regarded as passage of the nucleus to isomeric state. Observable small width of this transition, 8.2 eV, confirms such viewing. Empty (0,0) state means that observable 6Li with this structure can being the isomeric state. It is possible that lower isomeric states of lithium exist. From history of first thermonuclear bombs production, printed and open to any, we known that at testing of first soviet bomb the realized energy was much more less of expected. After adding the lithium shell the energetic of second test become big. If this is not the disinformation then it is strange. In my opinion, the experimental and theoretical efforts need for situation clarifying.

On the whole the results are acceptable.

$8Be$

This nucleus was not found in nature, it is unstable. First few energy levels of pn pair in 8Be are

state	energy
0,0	25.177
0,1	16.815
1,0	11.545
0,2	9.951
1,1	8.459
2,0	6.212
0,3	5.924

Because of 6Li structure, natural configuration of ground state is: (0,0) state is empty; each of (0,1) and (1,0) states contain two pn pairs. For this configuration the binding energy of 8Be is

$$4(0,1) + 4(1,0) = 56.72 \text{ [56.5]}$$

Small, 0.2 MeV, discrepancy with data means the stability of 8Be. Nonlinear electrostatic field is still small and cannot destroy the ground state of this nucleus. In this model, or counting of $N \neq 0$ states energy without usage of asymptotic procedure, or missing additional slow dependence of gluonic subtraction upon mass number are the sources of stable 8Be emerging.

8Be can be regarding as consisting of two virtual alpha particles, however, permitting the destroying of (0,1) state even for lower transitions. As for 6Li the natural restriction on allowed transitions is that the excitation of (0,1) state is possible if the alpha particle in (1,0) state is excited also. In this case the four lower lines are

$$4(1,0-0,2) = 3.19 \text{ [3.03]}$$

$$4(1,0-1,1) + 2(0,1-1,0) = 11.39 \text{ [11.35]}$$

$$4(0,1-1,1) + 4(0,1-1,0) = 16.76 \text{ [16.626]}$$

$$4(1,0-0,2) + 4(0,1-0,2)) = 16.92 \text{ [16.922]}$$

The nearness of third and fourth lines can have different sources. Beginning from 8Be the shells are mixed, however, the first mixings, (3,0)=3.589 and (0,4)=3.594, lay upper. Spin-orbital interaction cannot be the reason because in case of virtual alpha particle transition such splitting is questionable. The chance, as it is printed, can be the reason; the works need to clarify the mechanisms of the lines nearness.

With increasing of mass number the connection of theoretical and observable lines becomes not ambiguous, such 4(1,0-1,1) and 4(1,0-2,0) transitions are or were not observable. So for 8Be as well as for all next nuclei only the first transitions are calculating.

$10B$

The energies of few first levels are below

0,0	27.87
0,1	20.55
1,0	14.098
0,2	13.369
1,1	11.107
0,3	8.576
2,0	8.147
1,2	7.787

The configuration of ground state take with two empty lowest states and half empty (0,2) state

$$4(1,0) + 2(0,2) + 4(1,1) = 63.78 \ [64.75]$$

Here are the configurations which give the best fit of binding energy, however, for spectrum data such choice has preference.

Lower transitions, they have the isomeric nature, are

$$2(1,0-0.2) = 0.73 \ [0.718]$$

$$4(1,0-0.2) = 1.46 \ [1.74]$$

$$2(0.2-1,1) = 2.26 \ [2.154]$$

Remark that in usual models the calculated second transition also is below of measured. For next transitions the abundance of possibilities arise.

The results are acceptable.

$12C$

The energies of few lowest states are

$$(0,0) = 29.78,\ (0,1) = 23.40$$

$$(0,2) = 16.305,\ (1,0) = 16.168,\ (1,1) = 13.347$$

$$(0,3) = 11.050,\ (1,2) = 9.896,\ (2,0) = 9.825,\ (2,1) = 8.337$$

With empty (0,0) and (0,1) states and with virtual alpha particle in each of next three states, the binding energy of 12C is

$$4(0,2) + 4(1,0) + 4(1,1) = 91.64\ [92.16]$$

Because of symmetrical ground state, the little larger number of lower excitations is calculated

$$4(1,1-0,3) = 4.59\ [4.438]$$

$$4((1,1-\overline{1,2;2,0}) = 6.98\ [7.654]$$

$$4(1,1-2,1) = 10.02\ [9.64]$$

$$4(1,0-0,3) = 10.24\ [10.3]$$

$$4(0,2-0,3) = 10.51\ [10.844]$$

Unsatisfactory result for second, [7.654], line can be caused by cut-offing of pionic potential that made to avoid the complicating asymptotic procedure of Dirac equation solution.

Acceptable result it is. Again, the empty lowest states and abundance of possible upper transitions are the questions.

$14N$

The energies of lowest states are

$$(0,0) = 31.22;\ (0,1) = 25.64;\ (0,2) = 18.81$$

$$(1,0) = 17.895;\ (1,1) = 15.262;\ (0,3) = 13.320;\ (1,2) = 11.797$$

$$(2,0) = 11.305\ (2,1) = 9.860\ (0,4) = 9.429$$

From experience with previous nuclei the three lower states is assumed to be empty, the configuration of ground state take as

$$4(1,0) + 4(1,1) + 4(0,3) + 2(1,2) = 104.75\ [104.658]$$

what brings the well value of binding energy. Correspondingly, we expect that the excitations of pn pair from (1,2) state are the lowest transitions. In this case the first four acceptable transitions are:

$$2(1,2-0,4) = 2.368\ [2.312]$$

$$2(1,2-2,2) = 3.933\ [3.948]$$

$$2(1,2-0,5) = 5.052\ [4.915]$$

$$2(1,2-3,1) = 5.104\ [5.105]$$

The transition

$$2(1,1-2,0) = 3.957\ [3.948]$$

is acceptable also. The result for transition energies looks as well while it is bad indeed because many possible excitations were omitted. The absence of spin-orbital splitting is the question also. It seems that simple model reached his boundary. For completeness let us regard the next, 16O nucleus.

$16O$

The energies of lower states are

$$(0,0) = 32.35;\ (0,1) = 27.42;\ (0,2) = 20.96;$$

$$(1,0) = 19.360;\ (1,1) = 16.910;\ (0,3) = 15.377;\ (1,2) = 13.50;$$

$$(2,0) = 12.618;\ (2,1) = 11.227;\ (0,4) = 11.212;$$

If take into account the configuration of 14N ground state and add in (1,2) state the pn pair then binding energy of 16O deviated far of measured energy. The configuration of ground state as

$$4(1,0) + 2(1,1) + 4(0,3) + 6(1,2) = 126.88\ [127.619]$$

suits for binding energy and spectrum but this structure is as for odd-odd nucleus. Because the single pn pairs are presented the spin-orbital splitting of the lines is possible and the data confirm this. In 16O the many measured lines are de facto the doublets what is treated as spin-orbital splitting and the average values of the doublets is taking. Namely, the first and second lines [6.049; 6.1129] take as a single [6.09]; third and fourth [6.917; 7.116] as [7.02]; seventh and eight [9.582; 9.844] as [9.71].

In this case the assumed connection between calculated and observable lower lines is

$$4(1,2-2,0) + 2(1,1-2,0) = 6.06;\ [6.09]$$

$$6(1,2-0,4) = 6.86\ [7.02]$$

$$2(1,1-2,1) + 2(1,2-1,3) = 8.85\ [8.871]$$

$$6(1,2-1,3) = 9.50\ [9.71]$$

The reason of unobservable splitting for fifth line is obscured. The ambiguities, they are produced by lot of possible transitions, descend to lowest lines and the consideration of mirror nuclei is interrupted.

6.2.3 Discussion

These results offer additional argument for rejecting of the pure self-interaction in any field. In whole, that without binding with other fields the pure self-interaction of a field is source of infinite value for field energy and that the interaction with other field cut off the infinities is quite noticeable.

Taking into account the simplicity of the model, and not without exaggeration, the results on mirror nuclei structure are well.

The part of emerging questions is: the types of pionic potentials; the dependence of pionic as well as gluonic potentials on the mass number; the action of mass forces; the extensions in area of not mirror nuclei; the description of

electrostatic as well as spin-orbital interactions; the possible correlations between structures of nucleus and atom; the fit of data, including NN scattering, with various models of nuclear forces; etc.

The main question is the emptiness of lowest states. It looks as consequence of Coulomb-like spectra and perhaps can be removed by mass forces. However, it is possible that nuclei hang in energetic space. In my opinion as theoretical as experimental efforts need to clear up the situation.

6.3 Lightest not mirror nuclei structure

In not mirror nucleus, because the numbers of protons, p, and neutrons, n, are not equal between themselves, the pionic field has two strong charges. Semiclassical physics has no deal with similar objects, for description of not mirror nuclei the phenomenological, even Ptolemy-like, road is opening always.

Obviously, at first step the separation of the pionic and gluonic fields contributions to nuclei energies is desirable. The transition energies are independent on gluonic field subtractions so the nuclei spectrum is considering firstly. Comparing the observable value of binding energy and the calculated binding energy in pionic field for some assumed configuration of ground state the gluonic field subtraction per nucleon is calculated that restrict the area of excitation states, then turn around if the configuration of ground state was found contradictable.

The parameters of pionic field are modified as following. Because the depth of pionic well, G, is near expected value equal to double mass of free pion the one take as for mirror nuclei

$$G = 302.316 MeV$$

Pionic field dimensionless charge takes with simplest modifications as

$$Ga = k\frac{(A-1)}{2\sqrt{pn}}(A-1)^{2/3}S^{2/3}$$

$$k = 0.3908$$

$$S = 1 - k_1\frac{|n-p|}{\sqrt{p}}$$

where in the denominator the replacement $A \to 2\sqrt{pn}$ made because any nucleus contains at least one proton together with one neutron. The $|n-p|$ term is simplest for counting of the effects caused by proton-neutron difference, but we consider only the nuclei with extra neutrons. The constant k_1

is fitting parameter. In case $S < 0$ the isotope chains are interrupted and the denominator $\sqrt{p}$ is introduced for suitable restriction of the chains length.

Having calculated numbers for the nucleon energies in pionic field together with the spectra data the nucleus structure is recognizable.

Some additional remarks want to do.

Between structure of a nucleus and his isotopes the various correlations exist. If a nucleus has no as the excited states as a gap in ground state then the jointing of additional nucleon to this nucleus is impossible. If a nucleus has no the excitations but has a gap on a shell in ground state then additional nucleon may put on free space in ground state. For example, from data the deuteron has no excitations but it has half empty ground (N=0,l=0) shell, adding the neutron on this shell we get the triton. From data the triton has no excitation and its (0,0) shell is filled by neutrons so the next, Z=1 A=4, isotope is unrelated with the triton and has another structure. If in a nucleus the ground state filled up but the excited states exist then jointing of additional nucleon is possible to first, not forbidden for excitations, shell. The alpha particle is the example of such nucleus.

Another remark concerns to inertial forces acting on off-balanced in mass nucleons. Because the mass of a nucleon relative to mass of a light nucleus is not such small as it is for electron in atom, and because the vector part of w-field potential is $\sim R^{-2}$ and in general case the potential of w-field contain a scalar part, the inertial forces give a contribution to energies even if the velocity of a nucleon, v/c, is small. These forces are more essential for odd number of additional neutrons and for excitations of a nucleus. When the mass asymmetry and may be when the distance between unpairing nucleons and the center of field, the one does not coincide always with the mass center, are increasing these forces rise up. Because the abundance of excited states is typical for any shell model we qualitatively take the inertial forces into account to restrict the lot of excited states. Also, we assume that in not mirror nuclei typically only one shell, it is the first upper relative to ground state shell, is opening for excitation and that the more symmetrical distribution of masses in ground state is optimal. Even so the extra transitions stay on, they simply are neglected.

Because gluonic field act directly on the quarks and has no deal with nucleons we take for any nucleon in the nucleus the equal subtractions.

At once, in this shell model for fixed $N + l$ the less orbital momentum means the fewer binding energy of a nucleon in pionic field. Then typical hierarchy of a nucleon levels in pionic field is: (0,0); (0,1), (1,0); (0,2), (1,1), (2,0); (0,3), (1,2), (2,1), (3,0); etc.

Taking the triton as caliber for unknown constant calculation [below in

square bracket are data, 1MeV is unit of energy, the proton for Z=1 isotopes does not differ from neutron at energies calculations, the denomination of a nucleon energy in pionic field is (p,n,N,l)] we get

$$3(1,2,0,0) - 3(1,2,0,1) = 8.48[8.481]$$

$$k_1 = 0.2125$$

Correspondingly, the isotope chains lengths are: H=6[6], He=10[10], Li=14[12], Be=17[14], B=20[19], C=23[22], N=26[24], O=29[26], etc. The lengths of isotope chains are in not bad agreement with data so this parameterization of pionic potential is admissible.

For interested in subject reader is preferable instead of reading the following text to make the calculations about notmirror nuclei structure independently, and then compare the results. Using data are from NNDC tables.

$Z = 1$ chain

This chain contains four isotopes. The triton was taken for calibration of pionic field charge. Note, we regard a resonance as a state with negative binding energy of all nucleons. So the resonances of the triton cannot appear because at transition via (0,1) state the nucleons became the free particles and the nucleus break up. Because the quantity of the proton and neutron numbers is clear we simplify the denomination of the nucleon energies, labeling (N,l)=X instead of e(p,n,N,l)=X.

In $4H$ nucleus the calculated energies of nucleons in pionic field are

$$(0,0) = 6.040;\ (0,1) = 2.379;\ (1,0) = 1.990;\ (0,2) = 1.149$$

$$(1,1) = 1.108;\ (2,0) = 0.979;\ (0,3) = 0.664;$$

As was mentioned the structure of 4H and 3H differ. Natural conjecture is that it is similar to 4He structure then, because a state with zero orbital momentum cannot capture three neutrons, we assume that all nucleons of 4H are in (0,1) state. In this case the binding energy in pionic field is 9.516. Measured binding energy is [5.58], the needing subtraction per nucleon is 0.984, this is bigger of (2,0) state energy. Correspondingly, the (2,0) and all upper states are subject for resonance transitions. Because the energies of (0,2) and (1,1) states are almost equal we take the average value of the ones as $\bar{2} = 1.128$. On condition that the proton is spectator and only odd number of the neutrons can be transmitted (we do this assumption to restrict the

variety of possible transitions) the excitations are:

$$1(0,1) - 1(1,0) = 0.389[0.31]$$

$$3(0,1) - 2(1,0) - 1(\bar{2}) = 2.029[2.08]$$

$$3(0,1) - 1(1,0) - 2(\bar{2}) = 2.891[2.83]$$

$$3(0,1) - 3(\bar{2}) = 3.753[?]$$

Experimental searching of last excitation is desirable.

For $5H$ isotope the calculated nucleon energies in pionic field are

$$(0,0) = 6.241;\ (0,1) = 2.497;\ (1,0) = 2.077$$

$$(0,2) = 1.211;\ (1,1) = 1.166;\ (2,0) = 1.026$$

We guess that in 5He four nucleons are together and one aside; for this reason the ground state of 5H take with four nucleons in (0,1) state and one nucleon in (1,0) state. In this case the binding energy in pionic field is 12.065 while measured is [2.7]. So needing subtraction per nucleon is 1.87 and only internal excitations from (0,1) to (1,0) state are possible. No one excitation of this nucleus was observed. For reasons given the structure of 5H take as: (0,0) state is empty; in (0,1) state are two neutrons; on (1,0) shell are two neutrons and proton. In this case, because of 1.7 subtraction, the excitations are not possible, the resonances can be found in experiment. Lowest observable resonances (see[22] and references therein, it is accessible for me article) have energies [2.7 - 2.8], these values can be realized by transitions of three nucleons from (1,0) state. For example,

$$3(1,0) - 3(0,2) = 2.6;\ 3(1,0) - 3(1,1) = 2.73;\ 3(1,0) - 3(2,0) = 3.15$$

First 'true' resonance (in our schema 'true' because we regard a resonance as excitation of all nucleons in area negative binding energies, the unbound state is more suitable denomination of not-true resonances) is

$$2(0,1) + 3(1,0) - 5(0,2) = 5.2$$

but it was not found, at least on today.

For $6H$ nucleus the data are scarce, only the value of binding energy, [5.8], is in NNDC table. For 6He the data say it is the halo nucleus, for this reason we regard the 6H as halo nucleus also. This means that two neutrons of 6H

are moving in pionic field of core which is the 4H nucleus and so all nucleons are moving in p=1, n=3 pionic field. If the halo neutrons are in (1,0) state the binding energy of 6H in pionic field is 13.496 and needing subtraction per nucleon, 1.37, close all states of p=1, n=3 pionic field for excitations. One internal excitation of the proton from (0,1) to (1,0) state with 0.389 energy is possible if dividing of the one from 4H core is possible without breaking the nucleus. In own (p=1, n=5) pionic field the lot of excitations arise for any compatible with the value of binding energy configuration of ground state. Searching the excitations will clear up the structure of 6H nucleus.

$Z = 2$ chain

For simplicity the electrostatic energies will be ignored so the proton and neutron energies are identical. Because the ground state of 4He is without vacancies the extra neutrons are jointing to upper states.

In $5He$ nucleus the lower states of the neutron in p=2, n=3 pionic field are

$$(0,0) = 9.055;\ (0,1) = 4.516;\ (1,0) = 3.478;\ (0,2) = 2.359$$

If configuration of ground state is 2p(0,0)+2n(0,0)+1n(0,1) then, because mesuared binding energy of this nucleus is [27.41], the needing subtraction, 2.66, leaves the state (1,0) free for excitations. The first of the possible transitions is

$$1(0,1) - 1(1,0) = 1.038$$

the next corresponds to the excitations of alpha particle with energy near 20. In work [23] such structure was observable, for this reason the selected structure of 5He has advantage. However, because of maximal binding energy in pionic field, we expect the stability of this nucleus and observable unstable ground state stands up the question. Additionally, the 5He and 5H structures are not similar so or in the 5H are excitations or the puzzle arise in this model.

For $6He$ isotope, after looking on the nucleon energies in p=2, n=4 pionic field became clear they did not lead to satisfactory adjusting of the excitation energies. Because the experiments inclined the ones regard this isotope as halo nucleus we supposed that two extra nucleon of 6He as well as the nucleons of virtual alpha particle core are moving in pionic p=2, n=2 field. The energies of the neutron in this field are

$$(0,0) = 7.721;\ (0,1) = 3.471;\ (1,0) = 2.768$$

$$(0,2) = 1.744;\ (1,1) = 1.653;\ (2,0) = 1.410$$

With alpha particle on (0,0) shell and two neutrons in (0,1) state the nucleus energy in pionic field is 37.827, observable binding energy is [29.269]. Needing

subtraction per nucleon, 1.43, is somewhat bigger of (2,0) state energy and so this and upper states are subjects for resonance transitions. The gap between (0,2) and (1,1) states is small, for this reason we take the averaging energy of the last excited levels as $(\bar{2}) = (0, 2+1, 1)/2 = 1.698$. The agreements with data have following transitions

$$1(0,1) - 1(\overline{2}) = 1.773 \text{ [1.797]}$$

$$1(0,0) + 1(0,1) - 2(1,0) = 5.656 \text{ [5.6]}$$

$$2(0,0) + 1(0,1) - 3(\overline{2}) = 13.819 \text{ [13.9]}$$

$$2(0,0) + 2(0,1) - 4(\overline{2}) = 15.592 \text{ [15.5]}$$

$$4(0,0) - 4(\overline{2}) = 24.052 \text{ [24.2]}$$

Extra, not observable excitations were discarded. For today theory it is not bad result. However, the core has strange softness because one nucleon transitions from core are presented while for real alpha particle the (0,0) to (0,1) transitions are in facto suppressed.

Lower $7He$ neutron states in p=2, n=5 pionic field are

$$(0,0) = 10.094;\ (0,1) = 5.455;\ (1,0) = 4.099;\ (0,2) = 2.952$$

Observable binding energy of this nucleus is [28.82] and two excitations with [2.92; 5.83] energies were found in the experiments. These numbers say that only the (1,0) state is opened for excitations and here are few possibilities of the nucleons distribution on (0,0) and (0,1) shells. We take the cluster structure of this nucleus. Namely, single proton with two neutrons are in (0,0) state that corresponds to virtual triton, one proton with three neutrons are in (0,1) state as virtual 4H nucleus. Needing subtraction, 3.4, leaves only the (1.0) state free for excitations. The cluster model has some advantage because we can require that the nucleon transitions between clusters or break up the nucleus or lead to new cluster mode. In this way, because of Z=1 nuclei structure, the excitations from (0,0) to (0,1) state are forbidden. Also we assume that from virtual triton the odd number while from virtual 4H the even number of nucleons can be excited. With these restrictions the possible three excitations are

$$2(0,1) - 2(1,0) = 2.712; \text{ [2.92]}$$

$$1(0,0) - 1(1,0) = 6.0; \; [5.83]$$

$$3(0,0) - 3(1,0) = 18.0; \; [?]$$

This cluster model of 7He nucleus can be tested by searching the third excitation.

In $8He$ nucleus the neutron energies in pionic field are

$$(0,0) = 9.714; \; (0,1) = 5.098; \; (1,0) = 3.864; \; (0,2) = 2.721$$

and from experience with previous He isotopes we expect that states above of (1,0) belong to resonance transitions area. Taking into account that (1,0) state can take on board no more of two neutrons with two protons the lowest excitation energies are

$$1(0,1) - 1(1,0) = 1.234 \; [absent]$$

$$2(0,1) - 2(1,0) = 2.468$$

$$3(0,1) - 3(1,0) = 3.702$$

$$(2.468 + 3.702)/2 = 3.08 [3.1]$$

so the puzzle is with first excitation. Because $4(0,1) - 4(1,0) = 4.936$ transition is not presented in data we assume that (1,0) state contains one nucleon. With configuration 3(0,0)+4(0,1)+1(1,0) the (1,0) state is the last open for excitations as we assumed initially. Next transitions contain the single nucleons of (0,0) state (this is the reason for placing three nucleons in the (0,0) state), they are

$$1(0,0) - 1(0,1) = 4.616 \; [4.3]$$

$$1(0,0) - 1(1,0) = 5.850 \; [6.03]$$

For last observable on today excitation are few variants with almost equal energies, one of them is

$$1(0,0) + 1(0,1) - 2(1,0) = 7.084 \; [7.16]$$

Additional roads exist here. For example, if the possible excitation of two or three nucleons to (0,1) or (1,0) states will be not observable then (0,0) state is occupied by one nucleon only and the questions stand up.

In $9He$ nucleus the neutron energies in pionic field are

$$(0,0) = 8.358;\ (0,1) = 3.947;\ (1,0) = 3.095;\ (0,2) = 2.099$$

$$(1,1) = 1.900\ (2,0) = 1.600$$

Proper configuration of 9He ground state is: the proton with two neutrons in (0,0) state; one proton and three neutrons in (0,1) state; two neutrons in (1,0) state. In this case the binding energy of the nucleus in pionic field is 47.052 while observable binding energy is [30.26]. So needing subtraction per nucleon, 1.86, shut down the (2,0) and upper states for excitations, however (1,1) state can be forbidden also. For avoid this uncertainty we take the middle energy of (0,2) and (1,1) states, namely $(\bar{2}) = 2.0$. Two lowest excitations are

$$1(1,0) - 1(\bar{2}) = 1.095;\ [1.1]$$

$$2(1,0) - 2(\bar{2}) = 2.19\ [2.26]$$

In the next excitations the neutrons of (0,1) state are involved. Because (1,0) state is filled by neutrons we assume that neutrons transitions from (0,1) state lifted both neutrons of (1,0) shall. In this case

$$2(1,0) - 2(\bar{2}) + 1(0,1) - 1(\bar{2}) = 4.237\ [4.2]$$

$$2(1,0) - 2(\bar{2}) + 2(0,1) - 1(1,0) - 1(\bar{2}) = 4.989\ [5.0]$$

$$2(1,0) - 2(\bar{2}) + 3(0,1) - 3(\bar{2}) = 8.031\ [8.0]$$

$$2(1,0) - 2(\bar{2}) + 4(0,1) - 4(\bar{2}) = 10\ [?]$$

Last measured excitation has [8.0] energy so the nucleons of (0,0) state can be the spectators of the excitations. Also it is unclear why the proton from (0,1) shell does not fall to (0,0) state. Maybe such transition breaks up the nucleus but, because of electrostatic interaction between protons, it looks as electromagnetic process.

In $10He$ the energies of the neutrons in pionic field are

$$(0,0) = 4.809;\ (0,1) = 1.721;\ (1,0) = 1.493;$$

Maximal binding energy is reached when on (0,0) shell four and on (0,1) shell six nucleon are placed. In this case the pionic part of binding energy is 29.56

while measured binding energy is [30.34]. This absurd result requires the best tuning in the model if the 10He is particle.

$Z = 3$ chain

In *7Li nucleus* the neutron levels are

$$(0,0) = 11.847;\ (0,1) = 7.305;\ (1,0) = 5.304;$$

$$(0,2) = 4.243;\ (1,1) = 3.711;\ (2,0) = 2.916;$$

First observable excitation is small and far from next transition, of course for 7Li scales; only one transition, (0,2) to (1,1), has accordance with these. On this ground the structure of 7Li take as: three nucleons in (0,0), three in (0,1) and one in (0,2); the (1,0) shell is empty. For such configuration the binding energy in pionic field is 61.699 while observable is [39.244] and so the subtraction 3.21 reserve the (1,1) state for excitations. We restrict the number of possible transitions as: (1,0) state is closed for any transition; only odd number of nucleons can be transferred. Then suitable transitions are:

$$1(0,2) - 1(1,1) = 0.452\ [0.4776];$$

$$1(0,0) - 1(0,1) = 4.542\ [4.630]$$

$$2(0,1) - 2(0,2) + 1(0,2) - 1(1,1) = 6.576\ [6.680]$$

$$2(0,1) + 1(0,2) - 3(1,1) = 7.480\ [7.459]$$

$$3(0,1) - 2(0,2) - 1(1,1) = 9.638\ [9.67]$$

$$3(0,1) - 1(0,2) - 2(1,1) = 10.090\ [9.850]$$

$$1(0,1) - 1(0,2) + 1(0,1) - 1(1,1) + 1(0,0) - 1(0,1) = 11.118\ [11.240]$$

$$1(0,0) + 2(0,1) - 3(0,2) = 13.728\ [13.7]$$

$$1(0,0) - 1(0,2) + 2(0,1) - 2(1,1) = 14.632\ [14.7]$$

Here are possible but not observable excitations, they were skipped. The result for 7Li spectrum is acceptable , however it is achieved due to strange structure of this nucleus.

In $8Li$ *nucleus* the energies of the neutron levels in pionic field are:

$$(0,0) = 12.195;\ (0,1) = 7.711;\ (1,0) = 5.569$$

$$(0,2) = 4.551;\ (1,1) = 4.042$$

The value of the first observable excitation gives little doubts for placing in (1,0) state at least the one nucleon, because of 8He structure we take single nucleon in this state. However, the 8He and 8Li structures are nonidentical. We take for 8Li the structure of ground state as: four nucleons in (0,0), three in (0,1) and one in (1,0) state. Then, because of 41.277 value for observable binding energy, the needing subtraction is 4.526 per nucleon and the (0,2) state is the excitation level while the (1,1) state belongs to resonance levels. For this ground state the excitations, containing only odd number of nucleons and without involving the nucleons from (0,0) state, are

$$1(1,0) - 1(0,2) = 1.018\ [0.98]$$

$$1(0,1) - 1(1,0) = 2.142\ [2.255]$$

$$1(1,0) - 1(0,2) = 3.160\ [3.21]$$

$$1(1,0) - 1(0,2) + 2(0,1) - 2(1,0) = 5.302\ [5.4]$$

$$1(0,1) - 1(1,0) + 1(0,1) - 1(0,2) + 1(1,0) - 1(0,2) = 6.320[6.1]$$

$$3(0,1) - 3(1,0) = 6.426[6.53]$$

$$2(0,1) - 2(0,2) + 1(1,0) - 1(0,2) = 7.338[7.1]$$

$$2(0,1) - 2(0,2) + 1(0,1) - 1(1,0) = 8.462[9.0]$$

$$3(0,1) - 3(0,2) = 10.07[9.67]$$

Because the transitions from (0,0) state are not presented we can expect the existence of the alpha particle excitations with energy near 20 Mev.

Likewise, for $9Li$ nucleus the neutron energies in p=3, n=5 pionic field are:

$$(0,0) = 12.295;\ (0,1) = 7.832;\ (1,0) = 5.648;$$

$$(0,2) = 4.551;\ (1,1) = 4.117;\ (2,0) = 3.232$$

With restriction that even number of nucleons can be send from state to state the suitable excitations are:

$$1(0,2) - 1(1,1) + 1(0,1) - 1(1,0) = 2.711[2.695]$$

$$2(0,1) - 2(1,0) = 4.368[4.3]$$

$$2(0,1) - 1(1,0) - 1(0,2) = 5.372[5.38]$$

$$2(0,1) - 2(0,2) = 6.376[6.43]$$

$$2(0,1) + 2(0,0) - 4(0,2) = 17.678[17.1]$$

$$2(0,1) - 2(1,1) + 2(0,0) - 2(0,2) = 18.732[18.9]$$

This result is acceptable.

For next Z=3 isotopes the database still is not completed and we interrupt the calculations for this chain.

$Z = 4$ *chain*

In $9Be$ the levels in pionic field are:

$$(0,0) = 13.625;\ (0,1) = 9.521;\ (1,0) = 6.768;$$

$$(0,2) = 6.037;\ (1,1) = 5.225;\ (2,0) = 4.036$$

Let us take the ground state configuration as: four nucleons in (0,0), three in (0,1) and two in (1,0) state. Observable binding energy, 58.164, requires the subtraction 4.38 per nucleon what leaves the (0,2) and (1,1) states free for excitations. The lower of the ones are

$$(1,0) - (0,1) = 1.543;\ [1.684]$$

$$2(1,0) - (0,2) - (1,1) = 2.274;\ [2.429]$$

$$(0,1) - (1,0) = 2.753;\ [2.78]$$

$$2(1,0) - 2(1,1) = 3.086;\ [3.049]$$

For next excitation few variants available and we skip all the ones.

$10Be$ energy levels of the neutrons in pionic are:

$$(0,0) = 13.774;\ (0,1) = 9.722;\ (1,0) = 6.904;\ (0,2) = 6.214;$$

$$(1,1) = 5.364;\ (2,0) = 4.137;$$

It seems the configuration of ground state with three nucleons in (0,0) and seven in (0,1) state has preference. In this case the small excitations are absent and the single nucleon transitions from (0,0) state are allowed. Needing subtraction per nucleon leaves as excitation levels the (0,2) and (1,1) states. Compatible with data the lower transitions are

$$(0,1) - (0,2) = 3.508;\ [3.368]$$

$$2(0,1) - 2(1,0) = 5.636;\ [5.958;\ 5.959]$$

$$2(0,1) - 1(1,0) - 1(0,2) = 6.326;\ [6.179;\ 6.263]$$

$$2(0,1) - 1(0,2) - 1(1,1) = 7.176;\ [7.371]$$

$$(0,0) - (0,2) = 7.560;\ [7.542]$$

$11Be$ levels of the neutron in pionic field are

$$(0,0) = 13.788;\ (0,1) = 9.741;\ (1,0) = 6.916;$$

$$(0,2) = 6.230;\ (1,1) = 5.376;\ (2,0) = 4.147$$

The first observable excitation of this nucleus, [0.320], is so small that in whole beryllium chain is impossible to find the one. So we take the ground state of this nuclide with four nucleons in (0,0), seven in (0,1) and one in (1,0) state. In this case the needing subtraction is 5.0 that leaves the (0,2) and (1,1) states free for excitations. Suitable transitions are

$$(1,0) - (0,2) = 0.686;\ [0.320]$$

$$(1,0) - (1,1) = 1.540;\ [1.778]$$

$$(0,1) - (1,0) = 2.825;\ [2.690]$$

$$(0,1)-(0,2)=3.511;\ [3.410]$$

$$(0,0)-(0,1)=4.047;\ [3.887;\ 3.956]$$

$$(1,0)-(1,1)+(0,1)-(0,2)=5.051;\ [5.290]$$

$$(1,0)-(1,1)+(0,1)-(1,1)=5.905;\ [5.860]$$

$$2(0,1)-(1,0)-(0,2)=6.336;\ [6.510]$$

$$(0,0)-(1,0)=6.872;\ [6.705]$$

$$2(0,1)-2(0,2)=7.022;\ [7.030]$$

$$2(0,1)-2(1,1)=8.730;\ [8.816]$$

$$2((0,1)-2(1,1)+(1,0)-(1,1)=10.270;\ [10.590]$$

$$2(0,0)-2(1,1)+(1,0)-(1,1)=18.304;\ [18.50]$$

As for previous nuclei the extra theoretical excitations were skipped.

Of $12Be$ neutron levels in pionic field are

$$(0,0)=13.637;\ (0,1)=9.538;\ (1,0)=6.779$$

$$(0,2)=6.051;\ (1,1)=5.236;\ (2,0)=4.045;$$

With four nucleons in (0,0), six in (0,1) and two in (1,0) state the binding energy of 12Be in pionic field is 125.334, measured is [68.65], needing subtraction per nucleon 4.7, the (0,2) and (1,1) states are free for excitations. At assumptions that from (1,0) state even numbers of nucleons, from (0,1) odd numbers of the ones can be transmitted and the particles from (0,0) state have no part in the transitions the excitations of 12Be, which agree with measured values, are

$$2(1,0)-(0,2)-(1,1)=2.271;\ [2.102]$$

$$(0,1)-(1,0)=2.759;\ [2.702]$$

$$(0,1)-(1,1)=4.302;\ [4.560]$$

$$2(1,0)-(0,2)-(1,1)+(0,1)-(0,2)=5.758;\ [5.700]$$

Also the configuration of ground state with four nucleons in each of (0,0), (0,1) and (1,0) states is in agreement with measured on today spectrum of 12Be.

The spectra of next beryllium nuclides still absent in data tables and so, in this model, the structure of the ones is unclear.

$Z=5$ chain

Because the first observable lines determinate the structure of the nuclei we will regard the few lower transitions only. Note, beginning from boron the usual order of states is destroyed even for first levels, the energy module of (0,3) state is bigger of the one for (2,0) state. Along all this chain the difference between the energies of (1,0) and (0,2) states is near 0.3 what is smaller compare with the interval between these states and their first neighbors; these two states form the shell as it is in common approach where counting of radial quantum number keep off; the smallness of in-shell gap can be useful for determination of (1,0) state filling. For briefness the nucleon energies in pionic field are not printed.

$11B$ structure take as: four nucleons in (0,0), five in (0,1), the (1,0) is empty, two nucleons are in (0,2) state. In this case the (1,1) and (0,3) states are the upper state open for excitations. Assuming the even number of nucleons can be transmitted the lowest excitations for fitting of the two lowest measured ones are

$$2(0,2)-2(1,1)=2.346\ [2.184]$$

$$(0,2)-(1,1)+(0,1)-(1,0)=4.458\ [4.444]$$

or

$$2(0,2)-2(0,3)=4.866\ [4.444]$$

Big values of first excitations and absence of the transitions to which the 0.3 energy can be related caused the choice of 11B ground state with empty (1,0) state. Theoretical transitions, with which we can expect fitting of third observable line, are

$$(0,2)-(1,1)+(0,1)-(1,0)=4.461$$

$$(0,2)-(0,3)+(0,1)-(1,0)=5.718,$$

did not do this, however the middle value

$$(4.461 + 5.718)/2 = 5.080 \text{ [5.020]}$$

is acceptable. Three next theoretical transitions are

$$2(0,1) - 2(1,0) = 6.570 \text{ [6.742]}$$

$$2(0,1) - (1,0) - (0,2) = 6.888 \text{ [6.791]}$$

$$2(0,1) - 2(0,2) = 7.206 \text{ [7.285]}$$

Evidently, if the odd number of the nucleons will take part in transitions they destroy the result; this is the ground to allow the excitations of even number of the nucleons only.

For $12B$ nucleus the cluster structure of ground state, with four nucleons in each of (0,0), (0,1) and (1,0) shell, has some advantage. In this case the (0,2), (1,1), (0,3) and (2,0) shells belong to excitation states and suitable lower excitations are

$$4(1,0) - 4(0,2) = 1.188 \text{ [0.953]}$$

$$2(1,0) - (0,2) - (1,1) = 1.784 \text{ [1.637]}$$

$$4(1,0) - 3(0,2) - (1,1) = 2.378 \text{ [2.160]}$$

$$2(1,0) - 2(1,1) = 2.974 \text{ [2.723]}$$

$$2(1,0) - (0,2) - (2,0) = 3.316 \text{ [3.389]}$$

$$4(1,0) - 3(0,2) - (0,3) = 3.634 \text{ [3.759]}$$

These look as the excitations of virtual alpha particle which holds integrity at small perturbation but for bigger excitations lost the one, however the even number of nucleons is acting. For another structure of 12B the absences of the excitations which have the energies near 0.3 will require the explanations.

$13B$ ground state take with four nucleons in (0,0), eight in (0,1) and one in (1,0) state. In this case the subtraction 5.63 leaves (0,2) and (1,1) states in the excitation field. On the nucleon in (1,0) state assume that it cannot be transmitted alone. Suitable lower excitations are

$$(0,1) - (1,0) = 3.294 \text{ [3.482]}$$

$$(0,1)-(0,2)=3.604\ [3.534;\ 3.681]$$

$$(0,1)-(0,2)+(1,0)-(0,2)=3.914\ [3.712;\ 4.131]$$

$$(0,1)-(1,1)=4.783\ [4.829]$$

$$(0,1)-(0,2)+(1,0)-(1,1)=5.093\ [5.024;\ 5.106]$$

Double values of measured transitions we refer to spin-orbital splitting of the levels.

$14B$ ground state with four nucleons in (0,0), seven in (0,1) and three in(1,0) state is acceptable. In this case the gluonic field shut down the states above of (1,1) state and six available in database excitations can be fitted as

$$(1,0)-(0,2)=0.365\ [absent]$$

$$2(1,0)-2(0,2)=0.730\ [0.790]$$

$$(1,0)-(1,1)=1.498\ [1.380]$$

$$2(1,0)-(0,2)-(1,1)=1.863\ [1.860]$$

$$3(1,0)-2(0,2)-(1,1)=2.228\ [2.080;\ 2.320]$$

$$2(1,0)-2(1,1)=2.996\ [2.970]$$

Some of possible excitations were skipped.

For next Z=5 nuclides the database of NNDC does not contain the spectra and we consider the next string of nuclei.

In $Z=6$ chain the (0,2), (1,0) states are almost degenerated and form a shell. We will regard these two states as single and note the one as $\bar{2}$. The same is for (1,2) and (2,0) states which denominate as $\bar{3}$.

For $13C$ take the ground state as: four nucleons in (0,0), eight in (0,1) and one in (0,3) state. In this case the free levels are: $\bar{2}$, (1,1) and $\bar{3}$. The restrictions of possible transitions are: only the excitation of odd number of the nucleons is permitted, the excitation of the nucleon from (0,3) state alone is forbidden. In this case, skipping the extra transitions, the lower excitations are

$$(0,0)-(0,1)=3.175\ [3.083]$$

$$(0,1)-\bar{2}=3.601\ [3.684;\ 3.853]$$

$$(0,0)-\bar{2}=6.776\ [6.864]$$

$$2(0,0)-2(0,1)+(0,3)-\bar{3}=6.967\ [6.864]$$

$$(0,0)-(0,1)+(0,1)-\bar{2}+(0,3)-\bar{3}=7.393\ [7.492]$$

$$2(0,1)-2(\bar{2})+(0,3)-\bar{3}=7.814\ [7.547;\ 7.686]$$

$$(0,0)-(1,1)=8.231\ [8.20]$$

Note, the structure and forbidden rules for 13C are similar to the ones for 13B and 7Li nuclei.

$14C$ and 13C levels in pionic field differ on 0.001MeV. However, their spectral data are not coincide and we regard the ground state of 14C with four nucleons in (0,0) and ten in (0,1) state. Then (0,3) state is the last open for excitations. Possible transitions restrict allowing only even type of the excitations. In this case theoretical excitations and their assumed correspondence with data are

$$2(0,0)-2(0.1)=6.350\ [6.093;\ 6.583]$$

$$(0,0)-(0,1)+(0,1)-\bar{2}=6.776\ [6.728;\ 6.902]$$

$$2(0,1)-2(\bar{2})=7.202\ [7.012;\ 7.341]$$

$$(0,1)-(1,1)+(0,0)-(0,1)=8.231\ [8.317]$$

$$2(0,1)-\bar{2}-(1,1)=8.657\ [absent]$$

$$2(0,1)-\bar{2}-(0,3)=9.800\ [9.746;\ 9.801]$$

The correspondence between one calculated and two measured excitations can be caused as spin-orbital interaction as double nature of some states and pairing type of transitions.

For $15C$ the ground state take with four nucleons in (0,0), ten in (0,1) and one in (1,1) state. As a result the gluonic field lets (0,3) state as upper in the excitation set. Suitable for data fitting are the transitions

$$(1,1)-(0,3)=1.154\ [0.740]$$

$$(0,0)-(0,1)=3.204\ [3.103]$$

$$(0,0)-(0,1)+(1,1)-(0,3)=4.358\ [4.220]$$

$$(0,1)-\bar{2}+(1,1)-(0,3)=4.748\ [4.657;\ 4.78]$$

The $\bar{3}-(2,1)$ transition gives best fit of the first line. However, for opening $\bar{3}$ state the lower nucleons need move on upper states and extra transitions appear.

$16C$ database contains only six excitations and we can attempt to do more exact fit. Obviously, it can be reached distributing the nucleons between many states. This increase the number of possible transitions and gives possible to get best fit. However, the number of extra, not observable excitations will enlarge also. The neutron levels in p=6, n=10 pionic field are

$$(0,0)=15.580;\ (0,1)=12.310;\ \bar{2}=(0,2)=(1,0)=8.734;\ (1,1)=7.304;$$

$$(0,3)=6.129;\ \bar{3}=(1,2)=(2,0)=5.581;\ (2,1)=4.832;\ (0,4)=4.409$$

Let as take the ground state configuration as: four nucleons in (0,0), six in (0,1), four in $\bar{2}$, one in (1,1) and one in (0,3) state. The value of measured binding energy, 110.753, is reached with subtraction 4.76 and so the (2,1) is upper real state of 16C. Suitable schema, involving the even number nucleon transitions only, is

$$(0,3)-\bar{3}+(1,1)-(0,3)=1.723\ [1.766]$$

$$(0,3)-(2,1)+(1,1)-\bar{3}=3.020\ [3.027]$$

$$(0,0)-(0,1)+(0,3)-\bar{3}=3.818\ [3.986]$$

$$(0,1)-\bar{2}+(0,3)-\bar{3}=4.124\ [4.088;\ 4.142]$$

$$(0,1)-(1,1)+(1,1)-(0,3)=6.181\ [6.109]$$

The excitations of two upper nucleons look as if they are jointed and did not loss the hierarchy in the transitions. For excitations of lower nucleons the driving order to cut off the extra excitations is not noticeable easily.

In $17C$ the usual order of (1,0) and (0,2) states is restored, namely

$$(1,0) = 8.487;\ (0,2) = 8.384$$

With four nucleons in (0,0), ten in (0,1) and three in (1,0) state the transition

$$3(1,0) - 3(0,2) = 0.309\ [0.295]$$

fits existing on today the one measured excitation of 17C.

For $18C$ the data tables offer one excitation. With natural assumption that even number of nucleons is involved in interaction the explanation of observable number can be following. The transition of one nucleon from (1,1) to (0,3) state is supplemented by small in-shell (1,0)-(0,2) excitation, namely

$$(1,1) - (0,3) + (1,0) - (0,2) = 1.502;\ [1.620]$$

Then maximal packing of the nucleons in pionic field is: four in (0,0), ten in (0,1), three in (1,0) and one in (1,1) state. In this case needing subtraction, 5.002, leaves the (2,0) state in real area and the next predicted transition is

$$(1,1) - (2,0) + (1,0) - (0,2) = 1.785;\ [?]$$

So the plausible expectation is that observable [1.620] transition has double structure. Perhaps it can be checked with available data.

$Z = 7$ chain.

$15N$ structure take as: for nucleons in (0,0), six in (0,1), zero in (0,2) and four in (1,0) state. The subtraction 5.68 leaves (2,1) to be the last real state. On the lower excitations of this nuclide the following is assumed. Even number of nucleons is involving in transferring. The nucleons of (0,0) state are excited together and so they are not lower transitions. The (0,2) state keeps empty. The nucleons of (1,0) state are or excited at once or the nucleon of (0,1) state knock out a nucleon from (1,0) state and then stopped in (1,0) state or is going upper. Because the schema is complicated we regard more transitions. The lower excitations of 15N are

$$(0,1) - (1,0) + (1,0) - (1,1) = 5.208\ [absent,\ or\ 5.270]$$

$$4(1,0) - 4(1,1) = 5.284\ [5.270;\ 5.298]$$

$$(0,1) - (1,0) + (1,0) - (1,3) = 6.183\ [6.323]$$

$$(0,1)-(1,1)+(1,0)-(1,1)=6.529\ [6.323]$$

$$(0,1)-(1,0)+(1,0)-(1,2)=6.946\ [7.155]$$

$$(0,1)-(1,0)+(1,0)-(2,0)=7.194\ [7.155]$$

$$(0,1)-(1,1)+(1,0)-(0,3)=7.502\ [7.300]$$

$$(0,1)-(1,0)+(1,0)-(2,1)=7.919\ [7.567]$$

$$(0,1)-(1,1)+(1,0)-(1,2)=8.267\ [8.312]$$

$$(0,1)-(1,1)+(1,0)-(2,0)=8.515\ [8.571]$$

$$?\ [9.049]$$

$$4(1,0)-4(0,3)=9.176\ [9.151;\ 9.154]$$

$$(0,1)-(1,1)+(1,0)-(2,1)=9.240\ [9.222]$$

The [9.049] excitation falls out of the schema. The (0,2) state was taken empty because the transitions containing (0,2)-(1,0)=0.464 were not observed. Note, the electrostatic interaction begins to bring the detectable corrections of the spectra, they are ignored.

$16N$ structure cannot be simple because the lowest measured excitations are small. We take the ground state of this nucleus as

$$4(0,0)+5(0,1)+1(0,2)+3(1,0)+3(2,2)$$

In this case the subtraction, 4.343, leaves (3,0) state, which is above of (2,2), as last real state. We suppose that (1,0) state contains virtual triton and (0,0) state virtual alpha particle, which, at least for small energies, are excited as whole. Assumed connections between calculated and measured excitations are

$$(2,2)-(3,0)=0.143\ [0.120]$$

$$2(2,2)-2(3,0)=0.286\ [0.298]$$

$$3(2,2) - 3(3,0) = 0.429 \ [0.397]$$

$$(0,2) - (1,0) = 0.449 \ [0.397]$$

$$(0,1) - (0,2) = 3.430 \ [3.353]$$

$$(0,2) - (1,1) = 1.773 \ [absent]$$

$$(0,2) - (0,3) = 2.754 \ [absent]$$

$$(0,2) - (1,2) = 3.511 \ [3.523]$$

$$(0,2) - (2,0) = 3.751 \ [?]$$

$$(0,1) - (1,0) = 3.879 \ [3.963]$$

$$3(1,0) - 3(1,1) = 3.972 \ [3.963]$$

$$(0,1) - (1,0) + 3(2,2) - 3(3,0) = 4.308(\ [4.320]$$

$$(0,2) - (2,1) = 4.481 \ [4.391]$$

$$(0,2) - (0,4) = 4.700 \ [4.760;\ 4.783]$$

$$(0,2) - (1,3) = 5.034 \ [5.054]$$

The [4.320] excitation is realized somewhat artificially and the extra transitions are presented but in whole the result is acceptable.

$17N$ ground state take as

$$4(0,0) + 11(0,1) + 1(0,2) + 1(1,0)$$

Needing subtraction, 6.47, holds the (1,2) state in real domain. Assuming that (0,0) nucleons are transmitted by pairs the lower one nucleon transitions can be connected with observable numbers as

$$(0,2) - (1,0) = 0.410 \ [absent]$$

$$(1,0)-(1,1)=1.334\ [1.373]$$

$$(0,2)-(1,1)=1.744\ [1.849;\ 1.906]$$

$$(1,0)-(0,3)=2.335\ [2.526]$$

$$(0,2)-(0,3)=2.745\ [2.526]$$

$$(1,0)-(0,2)=3.073\ [3.128;\ 3.204]$$

$$(0,1)-(0,2)=3.447\ [3.628;\ 3.663]$$

$$(0,1)-(1,0)=3.857\ [3.628;\ 3.663]$$

The (0,2)-(1,2)=3.483 transition can be suppressed, it was omitted. Note, the middle value (3.447+3.857)/2=3.652 gives best fit of [3.628; 3.663] excitations.

$18N$ ground state take as

$$4(0,0)+3(0,1)+7(0,2)+2(1,0)+2(2,2)$$

needing subtraction is 4.181; because (3,0)=4.404 while (0,5)=3.935 the (3,0) is the last state of excitation set. The transitions restrict permitting the excitations from (0,2) and (2,2) states only with odd number of nucleons involved in. Possible connection between calculated and measured excitations is

$$(2,2)-(3,0)=0.107;\ [0.144];$$

$$(0,2)-(1,0)+2(2,2)-2(3,0)=0.556;\ [0.587];$$

$$2(0,2)-2(1,0)+(2,2)-(3,0)=0.793\ [0.747]$$

$$(0,2)-(1,1)=1.693\ [1.734]$$

$$2(0,2)-(1,0)-(1,1)+(2,2)-(3,0)=2.142\ [2.210]$$

$$3(0,2)-2(1,0)-(1,1)=2.377\ [2.420]$$

$$3(0,2) - 2(1,0) - (1,1) + 2(2,2) - 2(3,0) = 2.594 \text{ [2.614]}$$

On today these are all excitations offered by database.

$19N$ measured excitations are bigger of (0,2)-(1,0) energy and we take the mixture of these states as $\bar{2} = (9.519 + 9.280)/2 = 9.4$. Chosen configuration of ground state is

$$4(0,0) + 12(0,1) + 2(\bar{2}) + 1(1,1)$$

Odd number of nucleons can be transmitted only; it is expected restriction for the isotope with odd mass number. In this case the excitations are

$$(1,1) - (0,3) = 1.082; \text{ [1.11]}$$

$$\bar{2} - (1,1) = 1.496; \text{ [1.65]}$$

$$(1,1) - (1,2) = 1.738; \text{ [1.65]}$$

$$\bar{2} - (0,3) = 2.578; \text{ [2.54]}$$

$$\bar{2} - (1,2) = 3.234; \text{ [3.47]}$$

$$2(\bar{2}) - 2(1,1) + (1,1) - (0,3) = 4.074; \text{ [4.18]}$$

These are available on today measured excitations of 19N. Perhaps not single nature of [1,65] transition can be checked with existing data.

For next Z=7 nuclides the excitation spectra are absent, at least in NNDC tables.

$Z = 8$ chain

For $17O$ ground state the selected configuration is

$$4(0,0) + 11(0,1) + 2(1,2)$$

In this case the last excitation state is (2,0) and the transition

$$2(1,2) - 2(2,0) = 0.872 \text{ [0.870]}$$

gives good fit. So we assume that in lower excitations the even number of nucleons take part. Next excitations are

$$(0,0) - (0,1) + (1,2) - (2,0) = 2.927 \text{ [3.055]}$$

$$(0,1) - (0,2) + (1,2) - (2,0) = 3.690 \text{ [3.842]}$$

$$((0,1)-(1,0)+(1,2)-(2,0)=4.481\ [4.558]$$

$$2(0,0)-2(0,1)=4.982\ [5.084]$$

$$(0,1)-(1,1)+(1,2)-(2,0)=5.714\ [5.697]$$

$$(0,1)-(0,2)+(0,0)-(0,1)=5.745\ [5.732]$$

$$2(0,0)-2(0,1)+2(1,2)-2(2,0)=5.854\ [5.869]$$

There were skipped [5.215; 5.379] observable excitations; they can be considered as

$$(0,1)-(1,1)=5.278\ [5.215;\ 5.379]$$

It can be treated as special properties of not gamma transitions.

In $18O$ the energy interval between measured neighbouring excitations is small almost from second transition; that cannot be grasped by simple model reliably. Nevertheless, we continue the consideration of the isotope structure. Ground state of 18O takes as

$$4(0,0)+0(0,1)+12(0,2)+1(1,0)+1(1,1)$$

The empty (0,1) state produced small value of needing subtraction, 4.6, what lets many roads for excitations. The lower transitions restrict by even number of nucleons. Because the energy gap between (2,1) and (0,4) states is 6.300-6.327=0.023 we denominate these states as single $\bar{2}$. The transition from (1,0) to (0,3) is suppressed by big orbital momentum difference so this transition is discarded. First excitation series is

$$(1,0)-(1,1)+(1,1)-(0,3)=2.035\ [1.982]$$

$$(1,0)-(1,1)+(1,1)-(1,2)=2.956\ [absent]$$

$$(1,0)-(1,1)+(1,1)-2,0)=3.377\ [3.554]$$

$$(1,0)-(1,1)+(1,1)-\bar{2}=4.095\ [3.920]$$

$$(1,0)-(1,1)+(1,1)-1,3)=4.540\ [4.455]$$

$$(1,0)-(1,1)+(1,1)-(2,2)=5.089\ [5.097]$$

$$(1,0)-(1,1)+(1,1)-(3,0)=5.349\ [5.336;\ 5.377]$$

Next series are

$$(1,0)-(1,2)+(1,1)-(0,3)=3.754\ [3.633]$$

$$(1,0)-(1,2)+(1,1)-(1,2)=4.672\ [4.455]$$

$$(1,0)-(1,2)+(1,1)-(2,0)=5.193\ [5.097]$$

$$(1,0)-(2,0)+(1,1)-(0,3)=4.172\ [3.920]$$

$$(1,0)-(2,0)+(1,1)-(1,2)=5.093\ [5.097]$$

$$(1,0)-(2,0)+(1,1)-\bar{2}=5.514\ [5.530]$$

On the transitions from (0,2) state we assume that the lower ones contain four nucleons. Because in (1,0) state is the nucleon it is involved in the transition (0,2)-(1,0) also; then, because of supposed even structure of the excitations, the nucleon of (1,1) state is involved too. So the first excitation of (0,2) state is

$$4(0,2)-4(1,0)+(1,0)-(1,1)+(1,1)-(0,3)=5.095\ [5.097]$$

Here is the missing measured excitation which can be fitted as

$$(0,2)-(1,3)=5.305\ [5.254]$$

but this disagree with assumed even structure of the excitations. We estimate the results as acceptable.

$19O$ first excitation is small, [0.096], and does not change the parity of ground state. For this reason the suitable candidate for this transition is

$$2(2,1)-2(0,4)=0.126\ [0.096]$$

Ground state of 19O takes as

$$4(0,0)+9(0,1)+4(0,2)+2(2,1)$$

Needing subtraction, 5.779 leaves (0,4)=6.202 and (1,3)=5.788 states in real domain. However, the transition

$$2(2,1)-(0,4)-(1,3)=0.539$$

as well as the next possible excitation was not observable. On this ground we accept that, because of model roughness, the (1,3) state is in the resonance field. Next excitations involve the nucleons of (0,2) state. Assuming the even number of nucleons take part in lower transitions we get

$$2(0,2-1,0) = 1.438 \text{ [1.471]}$$

$$2(0,2-1,0) + 2(2,1-0,4) = 1.564 \text{ [1.471]}$$

$$3(0,2-1,0) + 1(2,1-0,4) = 2.220 \text{ [2.371]}$$

$$2(0,2) - (1,0) - (1,1) = 2.691 \text{ [2.779]}$$

$$2(0,2) - (1,0) - (1,1) + 2(2,1-0,4) = 2.817 \text{ [2.779]}$$

$$4(0,2-1,0) = 2.876 \text{ [2.779]}$$

$$4(0,2-1,0) + 2(2,1-0,4) = 3.002 \text{ [3.067]}$$

$$2(0,2-1,1) = 3.944 \text{ [3.944]}$$

$$2(0,2-1,1) + 2(2,1-0,4) = 4.070 \text{ [4.109]}$$

Here were missing two observable excitations, [3.153, 3.231]. It can be

$$(0,1-0,2) + (2,1-0,4) = 3.358$$

that is the first excitation of (0,1) state nucleons.

On $20O$ lower excitations the expression is that they are caused by nucleons of (0,2) and (1,0) states. We suppose that (0,2) contains only neutrons while (1,0) two neutrons and one proton and the even type of transitions is allowed. In this case the excitation of (0,2) always involve in the process the particles of (1,0) state. Suitable transitions are

$$(0,2-1,0) + (1,0-1,1) = 1.922 \text{ [1.675]}$$

$$(0,2-1,0) + (1,0-1,2) = 3.649 \text{ [3.570]}$$

$$(0,2-1,1) + (1,0-0,3) = 4.061 \text{ [4.072]}$$

$$(0,2-1,0)+3(1,0-1,1)=4.466\ [4.456]$$

$$2(0,2-1,0)+2(1,0-1,1)=4.844\ [4.850]$$

$$(0,2-1,1)+(1,0-1,2)=4.921\ [5.002]$$

$$(0,2-1,1)+(1,0-2,0)=5.274\ [5.234]$$

Here the first and [4.456] excitations have one variant, the others can be achieved by few ways, we printed the nearest to observable transitions. Without the consideration of higher transitions the structure of ground state is unclear.

$21O$ database contains five numbers. One nucleon transitions from (1,0) state can fit first four of them as

$$(1,0-1,1)=1.298\ [1.218]$$

$$(1,0-0,3)=2.223\ [2.133]$$

$$(1,0-1,2)=3.032\ [3.026;\ 3.073]$$

Because the similar following transitions were not observable we take the compact configuration of ground state. Namely,

$$4(0,0)+12(0,1)+4(0,2)+1(1,0)$$

In this case the subtraction 6.2 close (2,1)=5.922 and leaves (2,0)=6.691 state for excitation

$$(1,0-2,0)=3.329$$

which was not observable. So this excitation is suppressed or this discrepancy is the effect of model flaw. The five observable excitation can be fitted as

$$(1,0-0,2)+(1,0-1,1)=4.681$$

$$(0,1-1,0)+(1,0-1,1)=5.232$$

$$(4.681+5.232)/2=4.956\ [4.927]$$

and so it is the doublet that can be checked. On the transitions from lower states because of their filling, we expect the excitation of four nucleons at once. Even so the lowest transition from (0,2) state was not observable.

$22O$ chosen ground state is

$$4(0,0) + 12(0,1) + 4(0,2) + 2(1,0)$$

For this configuration the needing subtraction is 5.714 what leaves (2,0)=6.383 state and close (2,1)=5.655. Possible transitions restrict assuming that even number of nucleons take part in the interaction. First series of excitations, which is not lowest, is

$$2(1,0-1,1) = 2.664\ [absent]$$

$$2(1,0-0,3) = 4.658\ [4.582]$$

$$2(1,0-1,2) = 6.142\ [5.800]$$

$$2(1,0-2,0) = 6.586\ [6.509]$$

Next series include the neutron of (0,2) state on which we assume that it pick up the neutron of (1,0) state and both they are placed on the upper state. It is

$$(0,2-1,1) + (1,0-1,1) = 3.091\ [3.199]$$

$$(0,2-0,3) + (1,0-0,3) = 5.077\ [4.909]$$

$$(0,2-1,2) + (1,0-1,2) = 6.561\ [6.509]$$

$$(0,2-2,0) + (1,0-2,0) = 7.005\ [6.936]$$

This is acceptable result.

For next Z=8 isotopes the excitation database is empty.

The looseness of selected nuclei spectra is less compare with the ones for mirror nuclei. It can be estimated as a sign on the more complicated dependence of the gluonic subtraction upon the mass number. And the dependence of pionic field charge on the p-n difference can be the question also.

Simplest pionic potential, which gives $G^2exp(-2a/R)$ effective potential energy, was simplified at once as $g^2(1-2a/R+2a/R^2)$ to get the visible expression for nucleon energies in pionic field. Such cutoff of a potential on the big distances is typical for theoretical physics because about the properties of a potential in point R=0 nothing is known, the Coulomb potential is well example of this statement.

Because of pionic field spherical symmetry, the real inertial forces did not appear as well as virtual inertial forces generated by w-field for space-like type of w-field potential in the pionic field of a nucleus. Alike to interaction of the magnetic field with magnetic momentum of a particle the space-like w-field can act on the mechanical momentum of a particle.

In this model, anyone can find the questions which must be solved and the impression is that since Becquerel time the nuclear theory still is on the first degree of development.

If here are some printed errors, such as (0,1) instead of (1,0), informed me about the ones because two similar misprints were found by myself and they were reinstated after retyping; of this type errors happen not rarely, the example is the attempt of inserting the cite on S. Lang textbook.

7 Gluonic field

7.1 Free gluonic field

By physical meaning the gluonic field is primary field that binds the quarks in a hadron. Similarly to electromagnetic field this is four vector field with gradient symmetry and with four potential $G(x) = G_0\gamma_0 + G_n\gamma_n$ which is restricted by Lorentz gauge condition.

Physical differences with electromagnetic field are following. Electromagnetic field may exist in three forms: as charged electric field, as not charged magnetic field and as transverse waves while gluonic field always exist as charged field. On infinity the electrostatic field disappears, on small distances both the linear and nonlinear Coulomb potentials have singularity. Gluonic forces, as it is thinking today commonly, do not vanish on infinity. Gluonic potential has no singularities in center of field, moreover, here the forces vanish that is known as asymptotic freedom of strong interactions. As for any physical quantity these properties of gluonic field and the field existence itself are grounded on data and their theoretical interpretations.

We regard the gluonic field as classical object in static spherical symmetrical state. The potential of the one is $G\gamma_0 = g(R)$

Simplest state of any field is the free field. In classical physics, the lagrangian of free field always is square form of field tensions. If we take such lagrangian

$$L_0 \sim (\overrightarrow{\nabla} g)^2$$

then we get the Coulomb-like potential

$$g(R) = g_1 + \frac{g_2}{R}$$

which has infinite self-energy on small distances. Due to asymptotic freedom of strong interaction just the free gluonic field act in area of small distances and so the Coulomb-like potential is not being the potential of free gluonic field. We must accept that lagrangian of free gluonic field has more complicated form. If the one depends upon field tension only, then another, not Coulomb-like, solution of variation task exists. It is

$$(\overrightarrow{\nabla} g(R))^2 = constant$$

and it has no matter how complicated is the lagrangian of free field. In this case the potential of free gluonic field is following

$$g(R) = g_1 + g_2 R$$

where the constant g_2 determinate the scale of strong forces. It is fundamental quantity similar to electric charge in electromagnetic interaction. Remark, this is not faultless because it is general result and the unknown fields may exist.

As application example, regard the bound states of a particle in this field. Gluonic field tie up only the quarks but for simplicity regard a scalar particle in this field. For particle with mass m, energy E and orbital momentum l the Klein-Gordon equation for radial part of wave function is following

$$F'' + \frac{2}{R}F' = \left[\frac{l(l+1)}{R^2} + m^2 - (E - g_0 - bR)^2\right] F$$

Effective potential energy goes to minus infinity on big distances so this field is the unrestricted source of kinetic energy. If we do not believe in existence of the one then virtual inertial forces need take into account.

Yet, we regard free gluonic field. Radial part of particle wave function takes as follow

$$F(R) \sim R^l \prod_0^N (R - R_n) exp(AR + \frac{1}{2}BR^2)$$

Here restriction $ImE < 0$ is needing because the full wave function contain multiplier $exp(-iEt)$.

The solutions exist if the condition

$$m^2 = -ib(2N + 2l + 3)$$

is valid. So in this field only resonances are being and the square of their masses have linear dependence upon own spin.

From experiment such connection between the mass and spin of resonances is known few ten years. Firstly the Regge-pole then string models of strong interaction were established taking this connection as base [9]. However, the simplest tools of semi-classical physics enable to sight on high-energy physics phenomena.

7.2 On a quark confinement

Gluonic interactions have unusual property known as confinement - the quark as well as a gluon, the quantum of gluonic field, - are not observable in free states. For gluon this is natural because the free gluonic field has infinite self-energy, this is similar to situation with scalar photons which are not being seeing because the free electrostatic field does not exist. Because the mass of a particle is finite the confinement of quarks is striking phenomenon. In quantum field theory special mechanisms evoked for confinement of the quarks, [14] and [15], they are obscure still. At that time, it is hard to have the doubts that the some dynamics for confinement is not presented in quantum mechanics. Here the example of confinement in quantum mechanics is given.

Let us admit that gluonic field in not free state is usual physical field, then on infinity the potential of the one can be written as

$$G(R \to \infty) = G_0 + \frac{G_1}{R} + ...$$

For simplicity put $G_0 = 0$ and the potential energy, $V(R)$, of a quark in gluonic field cut off as

$$V(R) = \frac{g_1}{R} + \frac{g_2}{R^2} + \frac{g_3}{R^3} + \frac{g_4}{R^4};$$

Using the Schroedinger equation, that is reasonably for heavy quark, find the states of the 'quark+gluonic field' system. For easy viewing the dependence of the system spectrum at all, not one by one, quantum numbers the 'exact' solutions are searching. So the potential $V(R)$ is considered as being true on whole R-axis.

It is conveniently, replacing $F' = fF$, convert the Schroedinger equation to Riccati equation and get

$$f' + f^2 + \frac{2}{R}f = \frac{l(l+1)}{R^2} + 2m\varepsilon + 2m\Big[\frac{g_1}{R} + \frac{g_2}{R^2} + \frac{g_3}{R^3} + \frac{g_4}{R^4}\Big]$$

where $c = 1$, $\hbar = 1$ and m, ε, l are the mass, binding energy and orbital momentum of the quark. In this representation the form of wave function is

well noticeable. It is

$$f = D + \frac{B}{R} + \frac{A}{R^2} + \sum_{n=0}^{n=N} \frac{1}{R - R_n}$$

or

$$F = CR^B \prod_n (R - R_n) exp\big(DR - \frac{A}{R}\big)$$

where C, B, R_n, D, A are constants.

The case $D < 0$ reproduce the usual situation, we put $D = 0$. This restriction at once carries the condition $\varepsilon = 0$, and so the motion of a quark in gluonic field is free anywhere.

Nevertheless, the quark is binding. Indeed, in case $A > 0$ with condition $(B + N + 3/2) < 0$ the wave function is square-integrable and free motion of the quark take place in some middle area, on infinity as well as in center of the field the quark is unobservable. Uncertain physical meaning this situation has. May be the system is inaccessible for external strong interaction and so it is out of the hadron family. However, the same is not unlikely for any field and such wild situations are possible because for small perturbations the invisibility is typical property of any quantum system. Another interpretation is that the quark is a spectator. External perturbations do not change the quark energy, they modify the field energy. Here is the similarity to excitation of an electron on internal, not filled, shells in the atom if the energy of external electron is the constant. Of course, these do not mean the confinement. For realization of the one the spectrum of the system, it coincide with the gluonic field spectrum, must grow without limit when the numbers N, l increase. This is possible.

For calculation of two unknown constants A, B we have four restrictions from the central R^{-1}, R^{-2}, R^{-3}, R^{-4} singularities. The values of R_n constants are fixed by $(R - R_n)^{-1}$ singularities. Consequently, the parameters of gluonic potential are not all free, the two restrictions are on the ones.

All restrictions are:

$$A^2 = 2mg_4; \quad AB = mg_3;$$

$$2A \sum_n \frac{1}{R_n} = B(B+1) - l(l+1) - 2mg_2;$$

$$(B+1) \sum_n \frac{1}{R_n} + A \sum_n \frac{1}{R_n^2} = -mg_1$$

$$\sum_{k,\, k\neq n} \frac{1}{R_n - R_k} + \frac{A}{R_n^2} + \frac{B+1}{R_n} = 0$$

Summing the last equations we get

$$A\sum_n \frac{1}{R_n^2} + (B+1)\sum_n \frac{1}{R_n} = 0$$

Hence $g_1 = 0$, that is impossible for Coulomb field, but for gluonic field it is. Like situation is for intermolecular interactions because the potentials are similar.

Multiplied the last equations by R_n and summing we get

$$\frac{N(N-1)}{2} + A\sum \frac{1}{R_n} + (B+1)N = 0$$

The parameters $A > 0,\ g_2 > 0,\ g_4 > 0$ are regarding as unknown constants and so $B = B(N,l),\ g_3 = g_3(N,L)$;

After these simplifications the B-coefficient is

$$B = -N - \frac{1}{2} - \sqrt{(l+\frac{1}{2})^2 + mg_2}$$

For fixed N and big orbital momentum the B-coefficient is

$$B(l \to \infty) = -l,$$

this solution is unphysical for usual boundary conditions.

At first approach the excitations of gluonic field can be calculated as the average value of the field self-energies. Because of asymptotic freedom the main order of contributions to self-energies is

$$\int_R^\infty |g'(R)|^2 R^2 dR \sim R^{-3}$$

The $N = 0$ states are simplest for integration of R-degrees

$$\overline{R^{-1}} = \frac{2\|B\| - 3}{2A} \to \frac{l}{A};$$

$$\overline{R^{-2}} \to \frac{l^2}{A^2};$$

etc. The $g_3\overline{R^{-3}}$ and $g_4\overline{R^{-4}}$ terms have equal, $\sim l^4$, order and the suitable choice of g_4 constant makes the spectrum of field growing when orbital momentum of quark increase. Similar situation holds for the $N \neq 0$ states.

Hereby it is shown that in quantum mechanics the confinement phenomenon is possible, the boundary conditions are leading cause of its appearance, the growing of a field potential on infinity is unnecessary. Instead the some parameters of the field are not constants, a quantization of a field arise. The quark is spectator which does not take part in interaction. For electromagnetic and pionic fields the situation is opposite - the fields are the spectators with constant energy. These are because the free fields have different properties and so different boundary conditions exist. It will have interest if in some system the roles depend upon value of excitation energy.

The picture is much simpler of existing in quantum field theory that does not mean that it is more far from reality.

8 Clifford algebra

This is addition for reader who is not familiar with this algebra.

Any algebra is richer variety compare with vector space. In algebra the sum and the multiplication of elements with different algebraic structure are defined.

Is it possible the extension of the vector space variety to algebra? W. K. Clifford gives the answer in 1876 year. For this doing it is enough regard the coordinate vectors as matrices.

In physics, the space algebra L3 and the space-time algebra L4 are the essentials. Let us regard their properties briefly. Remark, from relativity principle it has no matter which coordinate system is using. But it became as standard to divide a vector on components. Which troubles this dividing create easy is seeing on example switching interaction of the electron with external magnetic field in quantum mechanics. We avoid such way. Then the flat coordinate system is using in general case (of course, the existence of the gravitation which deformed the space is ignored). Only when numerical calculations are doing the suitable coordinates are taking.

In space algebra the coordinate orts, $\vec{e}_n$, are equal to two dimension Pauli matrices with following properties

$$\vec{e}_n = \sigma_n$$

$$\vec{e}_i\vec{e}_k + \vec{e}_k\vec{e}_i = 0; \quad i \neq k$$

$$\vec{e_n}^2 = 1;\ n = 1, 2, 3$$

$$\vec{e}_1\vec{e}_2\vec{e}_3 = i1$$

The last matrix change sign at parity transformations so the imaginary unite of the complex numbers algebra at that time is the pseudoscalar of space algebra. Then general element in the space algebra is the sum of scalar, pseudoscalar, vector, and pseudovector.

The gradient operator in L3 algebra is following

$\overrightarrow{\nabla} = \vec{e}_n\partial_n$

Few examples of calculations in space algebra.

$\vec{a}\vec{b} = a_n b_k \vec{e}_n\vec{e}_v = \vec{a}\cdot\vec{b} + i\vec{a}\times\vec{b}$

$\overrightarrow{\nabla}(\vec{a}\vec{b}) = (\overrightarrow{\nabla}\vec{a})\vec{b} - \vec{a}(\overrightarrow{\nabla}\vec{b}) + 2(\vec{a}\cdot\overrightarrow{\nabla})\vec{b}$

$\overrightarrow{\nabla}R^N\vec{e}_z = NR^{(N-1)}\vec{e}_R\vec{e}_z = NR^{(N-1)}(cos\theta - isin\theta\vec{e}_\varphi)$

In algebra of space-time the coordinate vectors, u_n, are equal to four dimension Dirac matrices, $u_n = \gamma_n$, with following properties

$$u_i u_n + u_n u_i = 0;\ \ i \neq n;\ \ n = (0, 1, 2, 3)$$

$$u_0^2 = 1;\ u_s^2 = -1;\ s = 1, 2, 3$$

$$u_0u_1u_2u_3 = i_c$$

The last matrix change sign at inverse of the space as well as time directions, the standard is to denominate the one as $i\gamma_5$ matrix. We use almost the denomination of G. Casanova because here are two pseudoscalars which coincide at passing to space algebra. Remark, the existence of two pseudoscalars i, i_c in the space-time algebra commonly is missing as implicit standard. De facto the space and the space-time algebras are the complex varieties. General element in the space-time algebra is the sum of scalars, pseudoscalars, four vectors, pseudo-four-vectors and bevectors.

If A, B are two four vectors then bevector F is external multiplication of the ones

$$F = A \wedge B = \frac{1}{2}(AB - BA)$$

The matrices $e_n = u_n u_0$ are the four dimension anti-diagonal representation of Pauli matrices. So any bevector has other form

$$F = \vec{V} + i_c\vec{H}$$

where $\vec{V}$, $\vec{H}$ are the space vectors in four dimensional representation. This property makes easy the crossing between the space and the space-time algebras.

The gradient operator in L4 algebra is following

$$\nabla = u_0\partial_0 - u_k\partial_k$$

$$\partial_0 = \frac{1}{c}\partial_t$$

With common convention about the phases of physical quantities the operator of four impulse is

$$\hat{p} = i\hbar\nabla$$

Note that the definition of this operator with opposite sign is using widely.

Few examples of calculations in this algebra

$$\nabla A = \nabla u_0 u_0 A = (\partial_0 - \overrightarrow{\nabla})(A_0 - \vec{A}) = \nabla \cdot A + \nabla \wedge A$$

$$\nabla \cdot A = \partial_0 A_0 + \overrightarrow{\nabla} \cdot \vec{A}$$

$$\nabla \wedge A = -\partial_0 \vec{A} - \overrightarrow{\nabla} A_0 + i_c \overrightarrow{\nabla} \times \vec{A}$$

For more details see any textbook on Clifford algebra, for example [3] and [12], the links are in [11].

9 As summary

This article contains few news. The coherence condition and the direct solution of Dirac equation are technical tools. The w-field conception is physical assumption and it is working. Remark that any field has this w-field as shadow. We may regard this model as a description of virtual states in classical physics, especially if the local four impulse take as potential of w-field. However, in quantum field theory the local four impulse is the variable of integration but not the potential of a field.

The methods for elimination of the divergences of classical theory may be different [10]. For electromagnetic field the continual extension of classical field theory is almost trivial. For nucleus forces in simplest case the situation is even simpler than for electromagnetic field. However, for mechanical medium

the model is not extension, it is another way and by this or other manner this needs doing because the mechanical interaction travel with finite velocity.

Also in general case the density of energy in any physical field is not zero so one more shadow, however scalar, field may exist. Therefore, no one feedback may be in any physical field, just the free gluonic field example uses this circumstance. J guess these will have interest for physicist and will be useful.

10 To free physicists some proposals are making

Sturm – Liouville oscillation theorem

If the Sturm-Liouville oscillatory theorem is true anywhere then solving of Dirac equation for radial wave function can be reduced to algebraic task. From unknown reasons such method is not using. Maybe because the scientists, as any, inclined to go by common roads; maybe, I think, because the spectral, which is base, S-L theorem was proved for finite valued functions. Real potentials, they are spherical symmetrical mainly, are jointed with centrifugal term, $l(l+1)/R^2$, which is infinite on small distance. It will be well and well achievement if S-L oscillation theorem extend in area of real potentials. In last two years in this direction somewhat was made but for finite functions and intervals only. It seems a fresh glance needs here if we are not in the Godel area that is typical for theoretical sciences.

Gravity

For outsider the theoretical dealings with classical gravitation field look as swimming in the sea of indexes. Because for fermions the space-time is the Clifford algebra we can expect that for any systems this will be true. In my opinion, the presentation of the gravitation theory in Clifford form will be useful. On first look to do this is not hard. Indeed, any tensor, G_{ik}, is possible rewrite as A_iB_k. Then in Clifford algebra

$$G = AB = A \cdot B + A \wedge B = s + \vec{e} + i_c\vec{h}$$

is the sum of scalar and bevector, the last itself is the sum of three vector and pseudovector. After taking the suitable coordinate system the independent quantities are: s; v_x; h_x; h_y, just four parameters as for symmetrical tensor. The emergence of scalar field, s, does not bring a joy, it is enough the sigma meson in nuclear physics and Higgs in high energy physics. Maybe this scalar field is possible to avoid. Switching to other formalism is not empty work; on example of fluid dynamics is clearly that the appearance of new items is possible.

Another question concerns to electro-gravitation. This branch of gravitation theory is neglected by community entirely. This is because any vector field change sign at charge conjugation. But this assertion is no more than a convention. For example, looks on linear and nonlinear Maxwell equations for electromagnetic field

$$\nabla F = eu$$

$$\nabla F = gFuF$$

At charge transformation, $F \to -F$, the two possibilities are here:

or

$$u \to -u,\ g \to g,\ e \to e;$$

or

$$u \to u,\ g \to -g,\ e \to -e;$$

Because the fourvelocity is dimensionless quantity the second case has preference, I always use the last definition. Commonly the first case used by the implicit convention. The parameter u, which is the local fourvelocity of gravitation field when this field is regarding, can help to extend the gravitation theory and even rewrite the one in electro-gravity form, says in form of Maxwell equations.

Atomic physics

Here the theory is far away of experiment, the looks on the data and theoretical calculations of the ones is enough to comprehend the situation. Also here are some questions which should have resolved many years ago. One of them is the description of spin-spin interaction for simplest, spin half one, case. Here usual basic tool is the σ_z matrix. In Clifford algebra for spherical symmetrical field it is the $\vec{e}_R$ matrix. Because the spin is relativistic object $\vec{e}_R$ can be regarded as stemming from or γ_R (that correspond to vector part of electromagnetic potential) or $ii_c\gamma_R$ (this is connected with scalar part of potential) matrix. In first case the PT properties are wrong, additionally and mainly, for system with electric charge at least the local coordinate system exist where the vector potential is vanished while the spin is not equal to zero in any system. In second case PT-properties are true and s-s interaction is jointed with electrostatic potential. Such approach can be applied for data

fitting but the construction of general relativistic form for description of s-s interaction is desirable.

Nuclei

The conception of self-consistent field was built on the base of mechanics and it is hardly compatible with relativity, locality and causality principles. Another approach, created by Faraday and developed by Mie, when the field regards as the basic quantity, is rarity in physics (it seems that the Skyrme model is the unique example of working tool). Extended Yukawa potential of pionic field is pure field object which has no less firm ground than any potential in the physics. In my opinion it need making the efforts for clarifying: the dependence as gluonic as pionic potentials on proton and neutron numbers; the real contribution of Coulomb force in binding energies; the emergence of mass forces. Either independent-particles or fields itself picture is real belongs for essentials, if the computation tools permit the simultaneous comparison of two approach will have been making at data fitting. For education process extended Yukawa potential is fruitful.

In addition, from many and different reasons this article becomes long, invisible and hard for reading. If a reader gives to me the endorsement in physics or nucl-th parts of arXiv.org I will be grateful to him.

11 Acknowledgment

The author would like to thank Dr. Andre A. Gsponer for given possibility upload this article in arXiv.org.

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Nonlinear Classical Fields

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Abstract

We regard a classical field as a medium and so the additional parameter, the velocity of field, appears. If the one regards as a potential then all self-energies become finite. Electromagnetic, mechanical, pionic and somewhat gluonic fields are regarding.

Contents

1 Foundation

Internal contradictions of classical field theory are well known. Mainly these are the infinite self-energies of Coulomb and Yukawa fields. In 1912 year G. Mie [1] considered the electron as a state of electromagnetic field with main goal to eliminate the infinite self-energy of Coulomb field. His work gives the strong impulse for development of field theory and it has been created many works in this direction. But always the models were contradicted at least with one of general physical principles. For example, in Born -Infield model the analyticity principle was not fulfilled. In work of a French physicist [2] near 1972 year the current of a field was constructed but without C-symmetry. All these are because it is impossible to build the four-vector of electromagnetic current within the framework of electromagnetic field parameters only. Most texts on quantum electrodynamics, such as Landau-Lifschitz book (fourth paragraph), describe this impossibility in details.

Hence one of the ways for construction of a model for electromagnetic field without internal contradictions is to take into account an interaction of electromagnetic field with other fields. This task in area of quantum field theory

was done where the electromagnetic and week interactions were connected in single electroweak interaction.

In classical field theory as well as in area of low energy nuclear physics the infinite self-energies of fields remain. In this article the extension of classical field theory is considering with main goal to avoid the infinite self-energies of classical fields.

Main idea is following.

In general case any physical field has non-zero density of the mass. Therefore, any field has additional parameter, U, it is the four vector of the field velocity. The velocity or, for relativistic system, four velocity are usual parameters in physics, typically they are regarding as the properties of the particles. About a field velocity implicitly and always is assumed that it is equal to light velocity. This is doubtful because, for example, the electrostatic field of a resting particle has the three velocity equal to zero. We will regard the four velocity of a field as local parameter and so $U = U(x)$. Only in case when the field is continual variety of point-like not interacted between themselves particles the condition $U^2 \equiv 1$ is valid. In other words, a field is considering as special medium with two local parameters, they are the potential and four velocity of the field.

However, as parameter the four velocity exists for any physical object and in any case it is the essential quantity. At construction of any theoretical model for physical object, in today physics this means the lagrangian building, this parameter needs take into account. If this has done then either the four velocity is external parameter, similar to forces in Newtonian mechanics, or it is internal parameter. In last case the simple way is visible to reach up the complete system of differential equations. It is the consideration of $U(x)$ itself as a potential of some field. Then kinetic term, $(\nabla U)^2$, in lagrangian of a field removes all problems with setting the full and close equation system. Below the local four velocity of a field is regarding as a potential of some field which we call w-field.

Let us attempt to comprehend the physical meaning of this w-field. The tensions (forces) of the w-field are following (Clifford algebra, [3] and [12] [11], always is using)

$$\nabla U = \nabla \cdot U + \nabla \wedge U$$

$$\nabla \cdot U = \partial_0 U_0 + \overrightarrow{\nabla} \cdot \vec{U}$$

$$\nabla \wedge U = -\partial_0 \vec{U} - \overrightarrow{\nabla} U_0 + i_c \overrightarrow{\nabla} \times \vec{U}$$

In case $U^2 = 1$ the quantity $-\partial_t \vec{U}$ is usual mechanical acceleration with oppo-

site sign. Hence the w-field forces contain inertial forces. In typical case the square of four velocity is not equal to unit. The examples are: for scalar photons (these are electrostatic fields) $U^2 > 0$, for longitudinal photons (these are magnetic fields) $U^2 < 0$. We may feel almost certainly that by physical meaning the w-field is bearer of inertial (typically virtual) forces and expect that these forces create barrier which do not permit the concentration of a field in point-like object with infinite self-energy as it is in standard theories of interactions via fields.

Internal contradictions of classical field theory are sufficient for introducing of new essence. If we do not wish to do this then w-field may be regarded as representation, of course incomplete, of week forces in area of classical physics. For simplest approach, used in facto, the four velocity of a field is an external parameter.

If take into account the existence of w-field then it is not hard to build the lagrangian of fields (in other terminology - the Lagrange density of fields).

However, before the lagrangian construction we regard what is the coherence condition and some properties of wave function.

2 Coherence condition

Formally, this is trivial thing that is more simply understood in examples.

Regard the scalar field with potential $s(x)$ in one dimension space $x > 0$. The lagrangian of the field take as following

$$L = \frac{s'^2}{2} + ss'^2$$

The variation of the lagrangian is

$$\delta S = s'\delta s' + s'^2\delta s + 2ss'\delta s'$$

It is the sum of few terms and so more then one solution of variation task exist. Regard some of these solutions.

In case

$s'' = 0$

$s = a + bx$

the coherence condition is following

$$\int (s'^2\delta s + 2ss'\delta s')dx = 0$$

The variations in class of linear functions are

$\delta s = \delta a + x\delta b$

where $\delta a, \delta b$ are free numbers. Then

$$\int \left[b^2(\delta a + x\delta b) + 2b(a + bx)\delta b\right] dx = 0$$

Hence $b = 0$ and by physical meaning this is the vacuum state of the field.

Another solution is

$s'' = s'^2$

$s = a - ln(b + x)$

Coherence condition for this state

$$\int [a - ln(b + x)] \frac{dx}{(b + x)^3} = 0$$

connect between themselves the integration constants.

Next state is

$s''(1 + 2s) + 2s'^2 = 0$

$s + s^2 = a + bx$

with coherence condition

$$b^2 \int (\delta a + x\delta b) \frac{dx}{(1 + 2s)^3} = 0$$

In this state $b = 0$ and it is another vacuum state because the potential constants of states differ.

Generally used equation is

$$s'' + 2(ss')' = s'^2$$

without any restrictions for integration constants.

We see that single field with self-interaction exits in few states. Additionally, if some parameters are the fixed constants then variations of the ones are equal to zero and the coherence conditions for such parameters are automatically fulfilled (for example, electric charge is not variable constant). The coherence condition is strong tool for theoretical physics but it is unknown for most physicists.

3 Wave function and boundary conditions

For bound states of a particle in spherical symmetrical field the radial part of wave function take as following

$$F = CR^B \prod_0^N (R - R_i) exp(DR)$$

where C, B, R_i, D are the constants. In some cases the some of wave function zeros may be not single.

This form of wave function is settled on Sturm-Liouville oscillation theorem and might be considering as a generalization, or as a simplification, or as an extension of the one. Remark, in general case the coefficient C is finite, without zeros anywhere, analytical function on real R-axis which runs to constant on infinity. For physicist the infinity means the big, compare with some scale, distance. If the Taylor series of a function has arbitrary radius of convergence on real R-axis and on infinity the function is equal to constant then this function is constant anywhere.

The analyticity principle forced such type of wave function for Coulomb-like potentials. For example, in case of oscillatory potential the wave function on infinity has other behavior, $\sim exp(DR^2)$. So the main source of information about a system is contained in polynomial part of wave function. For some types of differential equations such solutions were known before the quantum mechanics appeared.

At first look this is trivial thing but the direct solution of differential equation is fruitful because the working with algebraic equations is more easy.

Let us determinate the additional boundary conditions for wave function in case when the potential of a field has a singularity in area of small distances. The exact mathematical solution of any equation is not the exact physical solution of the one. Have we deal with linear or nonlinear Coulomb field, or with any other field, always the area of small distances is unknown land. In this area all known and unknown forces are working. For example, the usual Coulomb potential has in center the singularity, e/R, which is non-physical because the one is not existing in nature, so it is true to regard the Coulomb potential on infinity only but not as the one having the singularity in center. For microscopic system the quantities that are visible on infinity have physical sense. In other words, for such systems the boundary conditions are invoked on infinity.

For this doing the Schroedinger equation divide on wave function, this means that the logarithmic derivative of wave function is using, and multiply the expression on R^X, where X is natural number. Then run the distance to infinity. Because on infinity the C-parameter is constant we get $X + 1$ algebraic equations, the ones fixed the unidentified parameters of wave function.

Which must be the number of these restrictions? It is must be equal to

number of unknown parameters. For example, count the ones for upper wave function. Here are the N unidentified wave functions zeros, constants D, B and energy E. For this case the degree of the multiplier is $X = N + 2$.

However, we may include in this list the parameters of the potential. If differential equation determinate all unknown constants it is well. If for some parameters the solutions did not exist then corresponding constants are regarding as external quantities. For almost all of this paper, the parameters of the potential consider as the externals.

Taking these boundary conditions we avoid the uncertainties connected with knowledge of physical quantities in not physical area of small distances. And this looks, because of simplicity, as trivial but only looks. Too widely the contradicting correlations between the parameters of the potential and wave function used to use. From these boundary conditions follow that a states with more wave function zeros contain more information about internal structure of the object. In other words, the precise measurements of energy levels may replace the high energy scattering experiments.

4 Nonlinear electromagnetic field

4.1 Lagrangian, current, Maxwell's equations

The lagrangian [4] of the pair interacting between themselves fields can be written as following

$$L = L_1 + L_2 + L_3$$

We regard the electromagnetic field with its shadow, the w-field, in area that does not contain any particle. As usually, this area is the whole space-time.

Four potential of electromagnetic field, $A(x)$, with tensions

$$F = \nabla \wedge A = \vec{E} + i_c \vec{H}$$

is restricted by Lorentz gauge condition $\nabla \cdot A = 0$

The lagrangian of free electromagnetic field is well known, namely

$$L_1 = \frac{F^2}{8\pi c}$$

Here in general case needs denominate the Dirac conjugation above of the one multiplier, for simplicity this sign is omitting.

The lagrangian for free w-field let us take in similar form

$$L_2 \sim (\nabla U)(\nabla U)$$

Quadratic dependence upon tensions for lagrangian of free electromagnetic field needs for compatibility with experimental Coulomb low. But for free w-field such form of the lagrangian is the assumption and it is strong assumption.

At first look about the interaction lagrangian nothing is known. It is true in general case but for electromagnetic field it is known enough. The four vector

$$\frac{\delta L_3}{\delta A} = J$$

is the density of current for electromagnetic field. For simplicity below we call this four vector or current, or jet. It is the source of electromagnetic field.

From Bohr correspondence principle the jet is linear function of four velocity and at all transformations the current has exactly the properties of four velocity. General form of such quantity is following

$$J = c_1 U + c_2(FU - UF) + c_3 FUF$$

where c_n are scalar functions which are independent upon velocity four vector. From gradient symmetry of electromagnetic field the ones depend on electromagnetic field tension F only.

The phase of any physical quantity is relative. This condition gives two restrictions. First limitation is $c_2 \equiv 0$. Second restriction is for argument of the coefficients - the scalar variable is F^2F^2 (one multiplier is conjugated).

Because here no the elementary particles with electric charge the condition $c_1(0) = 0$ must be valid. For usual transverse waves the current of the field is equal to zero that at once confirms this restriction.

Then in first not trivial approach the jet of electromagnetic field can be written as

$$J = \frac{c}{4\pi g} FUF$$

where the constant g determinate the scale of electromagnetic potential. This jet of electromagnetic field needs to compare with usual, eU, jet of a particle if the questions about C-symmetry arise.

For a current of w-field, $\delta L_3/\delta U$, all above arguments are true. Only the restriction on first coefficient is questionable, the interaction lagrangian may contain the term $L_3 \sim U^2$. For simplicity the self-interaction of w-field is neglected.

Four velocity is dimensionless quantity so it is convenient to take the potential of electromagnetic field in dimensionless form. It is

$$A(g, x) = gA(y = \frac{x}{a})$$

where g, a are the scales of the potential and length.

Correspondingly, the simplest action for electromagnetic field, which has the w-field as shadow and does not contain any charged particle, is following

$$S = \frac{e^2}{8\pi c} \int \left[(\nabla F)^2 + k^2 (\nabla U)^2 + 2A \cdot (FUF) + qU \cdot (FUF) \right] d^4 y$$

where all quantities after integration sign, including the variables of integration, are dimensionless.

This action does not contradict with any general physical principle. The scale invariance of this lagrangian is general property of any model for fields without external particles. By construction the validity area of this lagrangian is $O(F^4)$ and because the scale parameter is external quantity for description of macroscopic as well as microscopic systems the model can be applied.

Owing to constriction the jet is not variable by electromagnetic potential and the Maxwell nonlinear equations for dimensionless quantities are following:

in four-dimensional form

$$\nabla F = FUF$$

or, the same, componentwise

$$\nabla \cdot F = FUF$$

$$\nabla \wedge F = 0$$

in usual three-vector form

$$-\overrightarrow{\nabla} \cdot \vec{E} = u_0 (E^2 + H^2) + 2\vec{u} \cdot (\vec{H} \times \vec{E})$$

$$\overrightarrow{\nabla} \cdot \vec{H} = 0$$

$$-\partial_0 \vec{E} + \overrightarrow{\nabla} \times \vec{H} = \vec{u}(E^2 + H^2) + 2u_0 (\vec{H} \times \vec{E}) - 2\vec{E}(\vec{u} \cdot \vec{E}) - 2\vec{H}(\vec{u} \cdot \vec{H})$$

$$\partial_0 \vec{H} + \overrightarrow{\nabla} \times \vec{E} = 0$$

There always exist the solutions with potentials equal to constant anywhere. By physical meaning the ones are the vacuum states of fields.

The bevector of electromagnetic tension, Maxwell equations and Lorentz gauge condition are not changeable at transformation

$$A \to A + constant$$

Therefore for pure electromagnetic system the value of electrostatic potential on infinity is free number.

Using the coherence condition this equation system can make to be closed.

4.2 Closing equations of the field

Simplest state of electromagnetic field is that where the w-field is in vacuum state. In this case, taking into account the equality

$$A \cdot \big(FUF\big) = U \cdot \big(FAF\big)$$

the equation for four velocity is

$$\nabla^2 U = 0$$

Because this is the isolated equation the coherence condition take in form

$$\int (\delta U \cdot (FAF + qFUF)) d^4 y = 0$$

$$\int \delta_A J \cdot (2A + qU) d^4 y = 0$$

Next states we call the coherent states. In this case the equation for four velocity is

$$k^2 \nabla^2 U = FAF$$

with restrictions

$$\int \left[(2A + qU) \cdot \delta_A J + qU \cdot \delta_U J\right] d^4 y = 0$$

All other states involve in equation system the self-interaction of w-field, for simplicity we discard the ones here.

In this way the system of differential equations is completed.

Now regard the nonlinear Coulomb field.

4.3 Nonlinear Coulomb field

This is spherically symmetrical electrostatic field. Dimensionless potentials and the space variable of the field denominate as following

$$s(x) = A_0(x),\ u(x) = U_0(x),\ x = \frac{a}{R}$$

In this case the Maxwell equation is following

$$s'' = us'^2$$

where the denomination of scalar velocity is clear.

This electrostatic field has non-zero electric charge and non-zero density of electric charge what are the new phenomena not only for theory of classical fields.

In case of a system with full positive electric charge equal to unit the solution for tension is following

$$s' = exp \int_{s_0}^{s} u(s)ds = [1 - \int_0^x u(x)dx]^{-1}$$

In physical area, it is the area of big distances, the electrostatic potential is following

$$s = s_0 + x + s_2\frac{x^2}{2} + s_3\frac{x^3}{6} + ..$$

or for physical potential of the system with electric charge e

$$A_0 = \frac{es_0}{a} + \frac{e}{R} + \frac{eas_2}{2R^2} + ..$$

In this expression the coefficients s_i depend upon interaction constant of free w-field and from vacuum potential of electrostatic field. So implicitly the vacuum potential of electrostatic field is observable. In this point the nonlinear model differ from linear model where vacuum potential is free number. Of course, for different states these are different constants.

When the w-field is in vacuum state the equation for scalar velocity is the free field equation, namely

$$u'' = 0$$

$$u = u_0 + bx$$

Any physical field has finite self-energy. Hence the constant $b = 0$ and electrostatic potential in this state is

$$s = s_0 - \frac{1}{u_0}ln(1 - u_0x);\ \ u_0 < 0$$

Coherence conditions for these states are

$$\int (s + qu_0)s'^2 \delta u_0 dx = 0$$

$$\int (2s + qu_0)s' \delta s' dx = 0$$

then

$$u_0(s_0 + qu_0) = 1$$

$$u_0(2s_0 + qu_0) = 3$$

For system with positive electric charge the scalar velocity $u_0 = -1$. So $s_0 = -2$ and $q = -1$. This is very exotic state, below only the coherent states of electromagnetic field are regarding .

For coherent states the equation and solutions for scalar velocity are

$$k^2 u'' = ss'^2$$

$$u = -\frac{s}{k} + 2\sum_n \frac{1}{s - s_n}$$

with the equations

$$s_n = 2k \sum_{i \neq n} \frac{1}{s_n - s_i}$$

for determination of Hermitian numbers s_n, while the electrostatic tensions of these fields are

$$s' \sim \prod_0^N (s - s_n)^2 exp(-\frac{s^2}{2k}); \quad s'(0) = 1$$

so there are the variety of states similar to Glauber states.

For these coherent states always must be $s_0 > s_N$ then the self-energy of free w-field is finite number.

From physical reason, any motion on infinity is free motion. Correspondingly, the scalar velocity, u, on infinity has one of three possible values $u_+ = \{-1, 0, +1\}$. For states with positive electric charge $du/ds < 0$ and so in case $u_+ = +1$ these states have complicated electromagnetic structure because the density of electric charge change the sign in internal area of field.

Another example is the nonlinear electrostatic field of light nucleus. In nucleus the scalar velocity, u, depends upon parameters of the electromagnetic

and strong fields. In light nucleus the motion of nucleons is governed by strong interaction mainly. The distribution of nucleons is almost constant and their velocities are small compare with light velocity. Correspondingly, the scalar velocity of electromagnetic field in light nucleus is constant for first approach. In other worlds, in equation for determination of electrostatic potential the scalar velocity is external parameter which is equal to zero in external area and it is the constant in internal area of nucleus. However, the parameter u is not necessary equal to unit because a nucleon moves in cloud of virtual bosons but not in empty space. If b is the radius of light nucleus then the electrostatic tension is

$$E = \frac{eZ}{R} \qquad u_0 = 0 \qquad R > b$$

$$E = \frac{d}{R(R+b)} \qquad u_0 = const \qquad R < b$$

By physical meaning the constant d is the polarization of internal nucleus medium.

For that reason the distribution of electric charge in light nuclei at small distances essentially differs from the one in heavy nuclei.

Remark that for nonlinear Coulomb field the Earnshaw theorem may be not valid because the laplacian of electrostatic potential is not equal to zero.

Additionally, let us regard qualitatively the electron levels in nonlinear Coulomb field and the nonlinear electromagnetic waves.

4.4 Electron levels

The spin effects are essential here and the Dirac equation must be using. Electromagnetic field itself is four vector field but it is joining with spin framework. For example, electrostatic field of proton in general case is the sum of two terms with spins equal to 1/2 and 3/2. To avoid this, perhaps purely technical barrier, regard the electron connecting with alpha particle. The one has zero spin and the variety of data exist for He II levels. The Dirac equation for such systems has usual form

$$(i\nabla - eA)\Psi = m\Psi$$

$$c = 1,\ \hbar = 1$$

Let us go to usual three-spinors, separate the angle dependence of wave functions and convert two equations for two radial wave functions into one equa-

tion. Then the Schroedinger-like equation appears as

$$F'' + \frac{2}{R}F' + \frac{F'V'}{W-V} = \left[\frac{l(l+1)}{R^2} - \frac{fV'}{R(W-V)} + 2EV - V^2 + m^2\right] F$$

where E, V, m, j, l are the energy, potential energy, mass, momentum and orbital momentum of the electron; $W = E + m$; and $f = \{-l,\ (l+1)\}$ for $j = \{l + 1/2,\ l - 1/2\}$.
In this form the analytical properties of wave function are more realize.

Let us deviate from consideration of nonlinear field and regard the electron levels in the hydrogen for usual Coulomb field. In this case the denominator

$$W - V = W + \frac{\alpha}{R}$$

has single zero in the point $R_0 = -\alpha/W$ and two terms in the equation are singular. Thus we take the electron wave functions as

$$\Psi \sim R^B (R - R_0)^D \prod_{n=1}^{N} (R - R_n) exp(AR)$$

One of the emerging algebraic equation, $D^2 - 2D = 0$, has two solutions. The case $D = 0$, which corresponds to cancellation of the equation singularities, refers to well known situation available in all quantum mechanics textbooks, there the variety of main quantum number is {1,2,...}. If $D = 2$ the wave function has double zero and the main quantum number runs the variety {3,4,...}. So these novel states with main quantum number $n > 2$ are degenerated with the first ones while the states without or with one single zero of wave function are not degenerated. External electromagnetic field can take off this degeneration. For some reason the implicit assumption about singularities cancellation is used commonly, the existence of the solutions with double zero of the electron wave function was not considered, at least this is in accessible for me articles. Below we will regard the $n < 3$ states so the problem of levels degeneracy has no place. This piece of text is produced for slipping in the direction of physics after deep involving in the job of the digger for laying the water-pipe.

Now go back to nonlinear Coulomb field.

According to boundary conditions it is possible to make the following replacement

$$V \to V_0 - \frac{Z}{R} - \frac{Zau_0}{2R^2} - \frac{Za^2 s_3}{6R^3} + ..$$

and these are not the singularities in zero.

In Dirac equation the energy of electron and the term V_0, by physical sense the last is the interaction energy of the electron with vacuum, always are joined so below the last term is omitted when it itself is not required. Because the electric charge number and the fine structure constant are undivided the denomination Z instead of αZ is using frequently.

For calculation of unknown parameters the first four equations are

$$D^2 = m^2 - E^2$$

$$D(N + B + 1) = -EZ$$

$$B^2 + B + D(\frac{Z}{W} + 2\sum R_i) + 2BN + N^2 + N = l(l+1) - Z^2 - ZEas_2$$

$$D\left[\frac{Z}{W}(as_2 - \frac{Z}{W}) + 2\sum R_i^2\right] + 2(B+N)\sum R_i + (B+N+f)\frac{Z}{W} =$$

$$= -Z^2 as_2 - \frac{1}{3}ZEs_3 a^2$$

Neglecting by spin effects the He I levels regard roughly. Here the assuming scale of length is $ma = d/Z + ...$ Correspondingly, the binding energies of states with maximal orbital moment (N=0) are following

$$\varepsilon = \frac{m\alpha^2}{2}\left[1/2 + \sqrt{(l+1/2)^2 - du_0}\right]^{-2}$$

In He I the electric charge density on infinity is negative hence $u_0 = +1$ and the binding energy of the electron is bigger compare with linear model. From ionization energy data we roughly have $u_0 d = 0.2$ so with increasing of moment the spectrum quickly became hydrogen-like. The picture is true.

Regard the electron levels in He II (the alpha particle with one electron). Here on infinity the density of electric charge is positive and so $u_0 = -1$. Because electric charge is not concentrating in point all levels have shift up compare with levels in usual Coulomb field. Strong interaction between nucleons in nucleus ties up the particles - and so the electric charge with the ones - what may compensate nonlinear effects. Such is qualitative picture.

For calculation it needs to know the order of the scale parameter. It is

$$ma = .. + \frac{a_1}{Z} + a_0 + dZ + ..$$

Certainly, for He II in this sum the left coefficient is zero and the last is not zero. With middle coefficient is an uncertainty but from equations the one may put equal to zero. Remark, when asymptotic procedure of solution searching is using then we have not single-valued result and for separation of physical solutions it needs to use the correspondence principle. So the B-coefficient takes as following

$$B = j - \frac{1}{2} - \frac{Z^2}{2j+1} + bZ^2 + ..$$

correspondingly, the binding energy of the electron is following

$$\frac{\varepsilon}{m} = \frac{Z^2}{2n^2} - \frac{3Z^4}{8n^4} + \frac{Z^4}{n^3(2j+1)} - \frac{bZ^4}{n^3}$$

$$n = N + j + \frac{1}{2}$$

In states with maximal momentum (N=0) the nonlinear addition to binding energy is $b(2j+1) = -du_0$. The comparison with data and linear approach show that as the sign as the momentum dependencies of the supplement are true.

But let us regard the 2S, 2P states with momentum $j = 1/2$. In linear model these states are degenerate as any levels on fixed shell with equal momentum and opposite parity. In both these states the wave function has one zero. However, the ones have different order: not relativistic

$$mR_S = \frac{2}{Z} + ..$$

for S-state and relativistic

$$mR_P = -\frac{3Z}{4} + .$$

for P-state. Correspondingly, $b_S = -du_0 + ..$ in S and $3b_P = -du_0 + ..$ in P states.

So binding energy of electron in S-state is less of the one in P-state. This is the Lamb shift phenomenon. The value of Lamb shift is equal to $-u_0 dZ^4 mc^2/12$. From quantum electrodynamics calculations and from data

the value of Lamb shift is $0.41\alpha Z^4 mc^2$. This means that the value of parameter $-du_0$ is not sufficient for fitting the ionization energy of He II ion, the interaction energy of electron with vacuum can be taken into account and so the vacuum potential of electrostatic field for this system is directly observable quantity. Because at the estimation of the energies the s_3 and next coefficients were not working this result is grounded on analyticity principle mainly.

In usual model only the electric charge is external parameter, as result the electromagnetic system has zero size and infinite self-energy. In nonlinear model the charge and the scale of length are external parameters, all other quantities, including the self-energy of a field, are calculable. There has been the similarity with quantum electrodynamics where the electric charge and electromagnetic mass, the last determinate the space scale and vice versa, are external parameters of electromagnetic system.

4.5 Nonlinear electromagnetic waves

For classification of electromagnetic field states the signs of the invariants

$$E^2 - H^2;\ \vec{E} \cdot \vec{H};$$

are using. In nonlinear model somewhat another classification of the states is more convenient. Indeed, the square of electromagnetic jet is

$$J^2 \sim [(E^2 - H^2)^2 + (\vec{E} \cdot \vec{H})^2]u^2$$

Therefore, the states of the field are distinguishable via $u^2 = u_0^2 - \vec{u}^2$ sign.

The states with $u^2 \equiv 0$ contain the usual electromagnetic waves. In case $u^2 > 0$ the field has electric charge, these are the electric states of the field. If $u^2 < 0$ then these are the magnetic states of field, the ones have the electric charge equal to zero.

Correspondingly, at least the local coordinate systems exist where: the charged states have positive energy and zero impulse; the magnetic states have zero energy and not zero impulse. Of course, these did not mean that the magnetic states are moving with super light velocity. The example is the usual electric current in usual conductor. For magnetic and electric states the attribute 'velocity' has different physical meaning.

Typically, the electromagnetic waves are states without electric charge and with periodical phase. Thus nonlinear electromagnetic waves are magnetic states of the field.

For description of nonlinear waves it is conveniently to choose the coordinate system where the scalar part of electromagnetic potential is equal to

zero. From Maxwell nonlinear equations follow that the four vectors A, u are collinear then in appropriate coordinate system both scalar potentials are equal to zero, $A_0 = 0, u_0 = 0$.

It is conveniently take the four potentials of the field for flat electromagnetic waves as following

$$A = A(x)\gamma_y exp\{i(\omega t - kz)\}$$

$$u = -u(x)\gamma_y exp\{i(\omega t - kz)\}$$

With such choice of potentials the four tension of electromagnetic field is given by expression

$$F = (-i\omega A e_y + i i_c k A e_x + i_c A' e_z)\, exp\{(i(\omega t - kz)\}$$

what is more complicated form compare with usual description of the vector field without usage of Clifford algebra. However, the needing equations contain the amplitudes of potentials so this complication has no matter. If we wish divide the tension into electric and magnetic parts then the suitable phases need to take. The phase multiplier in potentials creates same theoretical trouble because this convert the vector field in mixture of vector and pseudo-vector fields. For simplicity we go round of that by usual manner - rewriting the definition of jets as $FuF \to Fu^+F,\ FAF \to FA^+F$.

Simplest waves are those where the w-field is in free state. Nevertheless, we consider the coherent states of the field.

For plainness, we regard only slow waves (put $\omega = 0$) and denominate the dimensionless amplitudes of the potentials as following

$$A(kx) = g\sqrt{k_{int}}p(s)$$

$$gv(s) = \sqrt{k_{int}}u(kx)$$

$$s = kx$$

where k_{int} is the interaction constant of free w-field.

Then from nonlinear equations for coherent states of the field the equations for calculation of dimensionless amplitudes follow in form

$$p'' - p = v(p'^2 - p^2)$$

$$v'' - v = p(p'^2 - p^2)$$

The symmetry $p(-x) = p(x)$ and boundary $p'(\infty) = 0,\ p(\infty) = constant$ conditions are taking that is suitable for paramagnetic waves. The last condition looks surprisingly because then the density of field energy on infinity contains a constant terms. However, the appropriate choice of interaction constant q in the lagrangian of electromagnetic field takes off the problem. In paramagnetic waves the local currents are parallel therefore, on ground of Ampere low, these waves are stable.

Few simple exact solutions of these equations exist. First is trivial $p \equiv v \equiv 0$ and it correspond to pure vacuum state of field. Second is $p \equiv v \equiv 1$, because the phase of fields is not zero these are the usual waves with fixed constant amplitudes. The solution $p \sim exp(\pm x),\ v \sim exp(\pm x)$ represent the free states of field, in this case the equations $p'' = p, v'' = v$ are equations of free field and the interaction between electromagnetic and w-field is absent.

Hence at least the free coherent nonlinear electromagnetic waves exist in the model. In these waves the field is concentrating near surface $x = 0$ and they did not have the internal structure along x-axis.

Apparently, the more complicated waves are here. For their detecting consider the example. Let us take the simplest connection, $v \equiv p$, between electromagnetic and w-field. By physical meaning the velocity parameter, v, is the polarization of vacuum with nonlinear dependence upon electromagnetic potential. The solution $p \equiv v$ correspond to linear connection between the polarization of vacuum and potential of electromagnetic field. For this case the first integral is

$$p' = \pm\sqrt{p^2 + C\,exp(p^2)}$$

and here are periodical solutions for potential if the first integration constant, C, is small negative number - then under square root expression is positive in area $p_- < p < p_+$. With conditions $p'(0) > 0$ the amplitude of potential increase at moving along s-axis and reach the value $p = p_+$ in same point $s = s_1$. After this point we may or put $p \equiv p_+$, or change the sign of the derivative. In last case the amplitude grow down to value $p = p_-$ in point $s = s_2$. These circles may be repeated not once but on big distances need to put $p \equiv p_+$, or $p \equiv p_-$. The situation is similar to usual trigonometric states where $p' = \sqrt{1 - p^2}$, therefore $p(x) = sin(x)$, or $p(x) \equiv \pm 1$. The energy of these states is the sum of the bits that gives additional chance for stability of these waves.

For axial symmetrical waves the electromagnetic jet is flowing along the axis of symmetry, or revolving about of the one. In first case the electromagnetic potential for slow waves take in form

$$A = A(\rho)\gamma_z exp(ik_1\varphi)$$

and similarly for potential of w-field. The variable ρ convert to variable $x = ln(\rho)$ then the equations for determination of field amplitudes are exactly the same as for system with flat symmetry. Then, for example, the field of free slow paramagnetic axial symmetrical wave is condensed near surface $\rho = 1$ what is similar to skin effect for usual neutral electric current in conductors.

In this way, the states of nonlinear electromagnetic field in form of nonlinear waves exist on paper. These states have richer structure than the usual electromagnetic waves. For theirs existence the external mechanical walls are not demanding.

Nonlinear waves interact with external electromagnetic field. Indeed, in this model all fields are interacting, however, not with themselves but with w-field. If take into account that any external field has fixed phase then it is easy to build the simplest lagrangian for interaction of nonlinear wave with external electromagnetic field. Because the usual electric jet itself is magnetic state we expect that all effects observable at spreading of usual electromagnetic waves via mechanical medium can be observable at spreading of nonlinear waves via as an external electromagnetic field as a medium because the last is the pattern of external field.

4.6 Numerical test of the model

Electronic spectrum of light ions is known with $10^{-7}eV$ exactness so the explicit calculations need to perform for testing the validity of nonlinear Coulomb potential. The He II ion, which is simplest among others, take for numerical testing. All constants are taking from NIST tables [7], in this subsection all energies and masses are presented in electron-volts. The fine structure constant is $\alpha = 7.297352568 \cdot 10^{-3}$. The electron, proton, neutron masses are

$$0.5109988918 \cdot 10^6;\ 938.2720029 \cdot 10^6;\ 939.565360 \cdot 10^6$$

Binding energy of alpha particle is $28.295674 \cdot 10^6$, thus the reduced mass of electron in He II is $m = 0.510928873 \cdot 10^6$. For our goal these data have the extra precision.

From Lamb shift data it is visible that the dimensionless scale parameter $ma = \alpha Zd$ has order $d \sim 0.01$. Correspondingly, for connection with Lamb

shift the precision of calculations for electron binding energy of order $O(\alpha^6)$ is enough, the B-coefficient needs to know with $O(\alpha^4)$ exactness.

Because the lagrangian itself is approximate construction the states with no more then one knot of wave function are considering.

Dimensionless scale, d, and the interaction constant of free w-field, k, are adjusting parameters. In first approach, when the motion of nucleons in nuclei is not counting, the nucleus effects are implicitly in adapted scale parameter.

With these conditions the calculated He II spectrum for states with maximal orbital moment in each shell (these are the states without knots of wave function) has coincidence with data that is not acceptable.

What is not true?

May be the nonlinear field? Dimensionless potential of Coulomb nonlinear field for N=0 states is

$$s = s_+ + \frac{Q}{R} - \frac{Qa}{2R^2}$$

and this form of the one follow directly from analyticity principle, only the sign of third term is resulting from nonlinear model. Because the scale parameter is fitting number this contribution of nonlinear model has no matter. For mistrusting in analytic principle, in addition the one is tightly connected with causality principle, we have no any reason.

Is Dirac equation incorrect in area $10^{-13}cm$? This is possible. However, the one work well enough in area of low energy nuclear physics where the scale is the same.

May be somewhat was missing in calculations? Yes, at estimation of electron levels in previous subsection we loose the w-field itself. In this model the electron moves in two fields. Electrostatic field act on the charge of the electron and it will be not strangely if the w-field act on the mass of the electron. By physical meaning the w-field may interact with any mass. Therefore, before reject the Dirac equation as not valid for electromagnetic interaction in area of small distances, we may attempt take into account the interaction of the electron with w-field. About this interaction nothing is known. The straightforward inclusion of a new terms in Dirac equation create, because of asymptotic conditions, the renormalization of charge. This is dangerous situation for any theoretical model because the measurement of fine structure constant carry out mainly from atomic spectroscopy experiments, short review of using methods is in [13]. However, it is plausible that in result of this mass interaction the effective mass of the electron is created. Then simplest way for counting of unknown forces is making the replacement in the expression for electron binding energy as following

$$m \to m + \delta m,$$

$$\frac{\delta m}{m} = g_1 a\overline{R^{-1}} + g_2 a^2\overline{R^{-2}} + ..$$

where, because the mass must be not renormalizable, the 0-term in series is zero. The electron energy in nonlinear Coulomb field is possible to write as series of $\alpha^2(B+N+1)^{-2}$ terms. Then we may take

$$\frac{\delta m}{m} = \frac{\alpha^2 Z^2 g_1}{(B+N+1)^2} + \frac{\alpha^4 Z^4 g_2}{(B+N+1)^4} + ...$$

without relying on averaging procedure. Moreover, any potential that contain on infinity the 1/R term generate the coulomb-like spectrum, the electromagnetic field and its shadow have identical algebraic structure so, for avoid the appearance of additional parameters, we are taking the deformed mass in form

$$1 + \frac{\delta m}{m} = \frac{B+N+1}{\sqrt{(B+N+1)^2 - g\alpha^2 Z^2}}$$

where g is unknown constant.

In this way the binding energy of the electron is (for simplicity we omit the vacuum potential of electrostatic field that has no matter for calculation of transition energies; of course, for ionization energy the value of vacuum potential is essential)

$$\varepsilon = mc^2 \frac{B+N+1}{\sqrt{(B+N+1)^2 - g\alpha^2 Z^2}} \Big[1 - \frac{B+N+1}{\sqrt{(B+N+1)^2 + \alpha^2 Z^2}}\Big]$$

As first approach let us consider the states without and with one (N=0 and N=1) knots of wave function. We take the simplest nonlinear potential energy

$$V = -\frac{\alpha Z}{R} + \frac{\alpha Z a}{2R^2}, \quad a = \alpha Z \frac{d}{m};$$

which de facto is produced by causality principle.

Then unknown parameters find using the data for (N=0, j=l+1/2) series.

The expressions for B-coefficients are

$$B(N=0, j=l+1/2) = l + \alpha^2 Z^2 \Big(\frac{-1}{2l+2} + \frac{d}{2l+1}\Big) -$$

$$-\alpha^4 Z^4 \Big(\frac{1}{(2l+2)^3} + \frac{d^2}{(2l+1)^3}\Big)$$

$$B(N=1, j=l-1/2) = l - 1 + \alpha^2 Z^2 \Big(\frac{-1}{2l} + \frac{d}{2l+1} \Big) -$$

$$- \frac{\alpha^4 Z^4}{8l^3}$$

At dubbing of unknown parameters the different mathematical programs return the somewhat different results, for taming the fitting procedure the small, d^2, terms in B-coefficient of (N=0, j=l+1/2) states was held. For (N=1, j=l+1/2) and (N=0, j=l+1/2) states the expressions for coefficients are identical.

With

$$d = 0.05634, \; g = 0.1487$$

the He II spectrum for N=$\{0, 1\}$ states is (observable values taken from NIST tables [7])

nlj	N=1, j=l+1/2 N=1, j=l-1/2 N=0, j=l+1/2	data
2s1/2	40.8130857	40.8130871
2p1/2	40.8130301	40.8130290
2p3/2	40.8137552	40.8137552
3p3/2	48.3715051	48.3715104
3d3/2	48.3715093	48.3715100
3d5/2	48.3715808	48.3715817
4d5/2	51.0167772	51.0167797
4f5/2	51.0167794	51.0167797
4f7/2	51.0167945	51.0167948
5f7/2	52.2411401	52.2411413
5g7/2	52.2411412	52.2411413
5g9/2	52.2411458	52.2411460
6g9/2	52.9062220	52.9062226
6h9/2	52.9062225	52.9062226
6h11/2	52.9062243	52.9062244
7h11/2	53.3072441	53.3072445
7i11/2	53.3072445	53.3072445
7i13/2	53.3072453	53.3072453
8i13/2	53.5675225	53.5675227
8k13/2	53.5675227	53.5675227
8k15/2	53.5675231	53.5675231
9k15/2	53.7459683	53.7459684
9l15/2	53.7459684	53.7459684
9l17/2	53.7459686	53.7459686
10l17/2	53.8736094	53.8736094
10m17/2	53.8736095	53.8736095
10m19/2	53.8736096	53.8736096
11m19/2	mixed	mixed
11n19/2	53.9680495	53.9680494
11n21/2	53.9680495	53.9680495
12o21/2	54.0398788	54.0398788
12o23/2	mixed	mixed
13q23/2	54.0957789	54.0957788
13q25/2	—	—
14r25/2	54.1401338	54.1401338
14r27/2	—	—
15t27/2	54.1759171	54.1759171
15t29/2	54.1759172	mixed
16u29/2	54.2052032	54.2052031
16u31/2	mixed	mixed
17v31/2	54.2294747	54.2294747
17v33/2	—	—
18w33/2	54.2498145	54.2498145
18w35/2	—	—
19x35/2	54.2670281	54.2670280
19x37/2	—	—
20x37/2	54.2817247	54.2817247

The last two quantities stand to almost Rydberg states. For example and comparison, the 20Y transition energy calculated with usual Coulomb field and without mass interaction is 54.2821688.

The binding energy of ground state is $\varepsilon = V_c + 54.4177630$ and in this model it is impossible to put the constant $V_c > 0$ equal to zero. Therefore the energetic gap between the states of electron in atom and in empty space exists in this model. If so then Rydberg states can be taken for energy accumulation. The measurement of the gap is reachable with today equipment because the now observable value of the electron ionization energy for He II is 54.418 eV.

As short summary, the nonlinear model stands upon numerical test. However, the theoretical problems with including of the mass, may be the energy, interaction with w-field arise.

4.7 Hydrogen levels

The proton has not zero spin and so its electromagnetic field contains a magnetic component. This gives rise to hyperfine splitting of hydrogen levels (for examples see the article [16] and references therein). For first approach this splitting can be neglected, in this case the expression for binding energies of the electron in hydrogen is the same as for He II in previous subsection. However, the values of fitting parameters (they are the dimensionless scale of nonlinear Coulomb field, d, and interaction constant of w-field with the mass of electron, g) differ. Again the simplest nonlinear potential energy is taken as

$$V = -\frac{\alpha Z}{R} + \frac{\alpha Z a}{2R^2}, \quad a = \alpha Z \frac{d}{m};$$

and the states with maximal momentum are using for calculation of unknown parameters.

With

$$d = 0.0731;\ g = 0.20193,\ m = 0.5107207446\ MeV;\ Z = 1;$$

the transition energies for N={0,1} states are following (the data are from NIST tables [7], 1eV is the unit of energy)

nlj	N=1, j=l+1/2 N=1, j=l-1/2 N=0, j=l+1/2	exp
2s1/2	10.1988147	10.1988101
2p1/2	10.1988058	10.1988057
2p3/2	10.1988511	10.1988511
3p3/2	12.0875071	12.0875066
3d3/2	12.0875065	12.0875065
3d5/2	12.0875110	12.0875110
4d5/2	12.7485395	12.7485394
4f5/2	12.7485394	12.7485394
4f7/2	12.7485404	12.7485404
5f7/2	13.0545020	13.0545019
5g7/2	13.0545020	13.0545019
5g9/2	13.0545023	13.0545022
mixed	mixed	mixed
6h9/2	13.2207036	13.2207035
6h11/2	13.2207037	13.2207037
7i11/2	13.3209178	13.3209178
7i13/2	13.3209179	13.3209179
8k13/2	mixed	mixed
8k15/2	13.3859607	13.3859607
9l15/2 9l17/2	13.4305539	13.4305539
10m17/2 10m19/2	13.4624511	13.4624511
11n19/2 11n21/2	13.4860515	13.4860514
12g21/2 12g23/2	13.5040014	13.5040014
13q23/2 13q25/2	13.5179708	13.5179707
14r25/2 14r27/2	13.5290550	13.5290550
15t27/2 15t29/2	13.5379972	13.5379972
16u29/2 16u31/2	13.5453157	13.5453157
17v31/2 17v33/2	13.5513811	13.5513811
18w33/2 18w35/2	13.5564640	13.5564640
19x35/2 19x37/2	13.5607656	13.5607656
20y37/2 20y39/2	13.5644383	13.5644383
limit	13.5984340	13.5984340

Today observable ionization energy is 13.5984 eV and so the vacuum potential of hydrogen field compare with He II field is small. It is strange because for electrostatic vacuum potentials we are expecting the validity of superposition principle.

Let us compare the hydrogen and HeII results.

Little more best agreement with data for N=0 states of the hydrogen atom seems natural because in low energy area the structure of the proton is simple of alpha particle structure.

Well agreement with data for (N=1, j=l-1/2) states of hydrogen is surprising result. Possible treatment of that is following. Spin-orbital splitting of the levels has not dynamical origin, it is caused by algebraic structure of Dirac equation, the effective potential of R^{-2} degree is valid as for N=0 as for N=1, j=l-1/2 states. Asymptotic procedure of differential equations solution generate the series of effective potentials which are the polynomials of 1/R. At solving of Schroedinger equation by usual manner the odd degree potentials have nonfunctional analytic properties and can be discarded. When boundary conditions was settled then the way of computations is the question of the comfort only, so the restriction on potentials of odd degree can be valid as first approach.

The agreement with data for N=1, j=l+1/2 states is worse and the next effective potential (if odd degree are forbidden it is R^{-4} type of potential) needs involve in computations. For N=1, j=l+1/2 state, independently the R^{-3} or R^{-4} potential is using, the additional term in potential energy arise. It is $-\alpha s_3 a^2/(3R^3)$ where $s_3 = (us'^2)'_0 = 2 - 1/k - 2\sum 1/(s_0 - s_n)^2$. So we expect that the s_3 coefficient is negative, of α^{-2} order, constant. For hydrogen this circumstance permit the improving of the fit for 2s1/2 series. But the He II fit require the positive value of this constant. This means that motion of protons in nucleus, which decrease the repulsive forces and then increase transition energies, want to count. However, the unexpected essences are not forbidden here.

Experimental binding energies have smooth dependence upon orbital momentum. Nevertheless, the fitting of the energy is not trivial task and nonlinear Coulomb potential gives natural ground for calculation of atomic properties. Of course, the computations as hyperfine splitting as next transition energies are desirable.

4.8 Levels of Li I

Since N. Bohr, because of experimental physicists achievements, the atomic spectra did not have to become simple for theoretical calculations. To ob-

tain the correspondence with data even in case of few lines of simple atom the needing work is huge, see [17] and references therein. Of course, the computations are true if using models are true.

However, the spherical symmetrical potential energy, $V(R)$, of the valence electron in the atom, without relying on a model, on big distances can be decomposed in series

$$V = V_0 + \frac{V_1}{R} + \frac{V_2}{R^2} + ..$$

Then, regarding V_i as free parameters, anyone can perform a fit of the data and in this way to check the analyticity principle directly. I had done this for Li I 2s1nl states, which are simplest between the ones, with usage of nonlinear model for electromagnetic field which brings the independence of two coefficients only. It has been fruitlessly.

What the matter is? The analyticity principle is the hardest base of theoretical physics. The hint for escapement was found in interesting work [18] where thermodynamic formalism is applying to pure mathematical system. The solution is: global, $0 < R < \infty$, analyticity is absent, at least the single point, $R = R_0$, exists where the electrostatic potential fails to be analytic. Physical underpinning of such situation can be found easy. For clearness we regard LiI 2s1nl states only. The density of negative electric charge produced by two electrons on s-shell is $\sim exp(-\alpha R/R_0)$. Correspondingly, in area $R > R_0$ the valence electron is moving in some kind of field gas created by cloud of virtual scalar photons while in area $R < R_0$ the motion is in some kind of field liquid. So the atom is the system with internal phase structure. Of course, it was assumed implicitly that electrostatic potential of the atom is the sum of nucleus and electronic potentials, in first approach this is true.

All electrons in the atom are near mass shell, in first approach their scalar velocities, $u_0(R)$, are near unity, $|u_0| = 1$. Because the nonlinearity of negative electrostatic field is caused mainly by motion of the electrons the nonlinear Maxwell equation, $s'' = u_0 s'^2$, leads to following potential of electronic cloud

$$\varphi = -\frac{2e}{R_0} ln\Big(1 - \frac{R_0}{R}\Big)$$

where for moving the singularity in physical area the value $u_0 = 1$ was selected. Correspondingly, the decomposition of the potential in series with infinite radius of convergence is impossible and the 'exact' solutions must be found. Remark, this potential depends on $(R - R_0)$ variable. At usual consideration, when the creators of the fields are dotty particles but not the fields itself, the electron correlations dependence on $|\vec{r}_1 - \vec{r}_2|$ variable.

It is cumbersome to work with logarithmic potential and for first approximation the potential energy for last electron in Li I take in form

$$V = -\alpha\frac{3}{R} - \alpha\frac{a_1}{R^2} + \alpha\frac{2}{(R-R_0)} - \alpha\frac{a_2}{(R-R_0)^2}$$

where we held the first nonlinear terms and all scales have equal order, namely

$$a_1 = \frac{a}{\alpha m};\;\; R_0 \sim \frac{1}{\alpha m};\;\; a_2 = \frac{b}{\alpha m};$$

For logarithmic derivative, $f = F'/F$, of radial wave function, $F(R)$, the Dirac equation reads

$$f' + f^2 + \frac{2}{R}f = \frac{l(l+1)}{R^2} + m^2 - W^2 + 2WV - V^2$$

where, because of spin-orbital interaction smallness, the terms with derivative of potential were neglected; the term $W = E - V_0$ contains the energy, E, and vacuum term, V_0, which in nonlinear model is not equal to zero. For internal compatibility in V^2 only square terms hold on

$$V^2 \to \alpha^2\Big(\frac{9}{R^2} + \frac{4}{(R-R_0)^2} - \frac{12}{R(R-R_0)}\Big)$$

The solutions search in form

$$f = A + \frac{B}{R} + \frac{D}{R-R_0} + \sum\frac{1}{R-R_n}$$

that leads to algebraic equations for determination of unknown constants, $E,\ A,\ B,\ D,\ R_n,\ R_0$, including R_0 because it is the one of the wave function knots. So the electron correlations are too strong.

Binding energy is

$$\varepsilon = V_0 + m_{ef}\Big[1 - \frac{n_{ef}}{\sqrt{n_{ef}^2 + \alpha^2}}\Big]$$

$$n_{ef} = n + B - l + D$$

where $n = N + l + 1$ is usual main quantum number which begin running, because of extra knot of wave function, from number two, $n = \{2, 3, ..\}$.

The expressions for other coefficients are

$$B_0 = -\frac{1}{2} + \sqrt{\big(l + \frac{1}{2}\big)^2 - a}$$

$$D_0 = \frac{1}{2}\Big[1 - \sqrt{1 - 8b}\Big]$$

$$n_0 = n + B_0 - l + D_0$$

$$B = -\frac{1}{2} + \sqrt{\Big(l + \frac{1}{2}\Big)^2 - 9\alpha^2 - a\Big(1 - \frac{\alpha^2}{2n_0^2}\Big)}$$

$$D = \frac{1}{2} - \frac{1}{2}\sqrt{1 - 16\alpha^2 - 8b\Big(1 - \frac{\alpha^2}{2n_0^2}\Big)}$$

In D-coefficient the solution with minus sign of square root is selected from reason that Rydberg correction must change the main quantum number slowly. In case of small D this choice leads to infinite averaging potential energy. Because the full energy is finite we omit this question. Formal α^2 exactness of these coefficients provide of E/m exactness between α^4 and α^6.

Parameter m_{ef} is the effective mass of electron

$$m_{ef} = m\frac{n_{ef}}{\sqrt{n_{ef}^2 + g\alpha}}$$

$$m = 0.5109523\ MeV;\ \alpha = 0.007297352568;$$

It is external quantity which does not follow from Dirac equation, it was revealed at H and He II spectra fitting that additional mass interaction exists with α^4 strength. Correspondingly, we apply this result to atomic spectra also.

In this way we have three dimensionless parameters, a, b, g, with obscure unknown vacuum energy, V_0. It is possible, and the pilot fit confirm this, that V_0 depends upon quantum numbers. For avoiding this complication the limit of transition energies extrapolated in NIST [7] use at fit of the spectra, namely

$$\varepsilon_{tr} = 5.3917191\ eV - \varepsilon(n, l) + V_0$$

And this is not all. The electron with nonzero orbital momentum intersect the phase boundary while the s-electron is or in gas on in liquid phase without crossing the boundary. From this reason, which was produced by pilot fit, the $l = 0$ states will be regarding separately. In addition to these the states with

maximal orbital momentum are under suspicion because they have no knots of wave function. NIST table contains only few of these states, (2,1; 3,2; 4,3), they are out of consideration.

The values of fitting parameters for $l > 0$ states are

$$a = 0.3083,\ b = 0.62697,\ g = 7.72$$

and for $l = 0$ states

$$a = 0.1421,\ b = -0.1375,\ g = -10.255$$

Negative and positive values of b have simple geometric meaning. In both cases all particles are on one line and two not valence electrons are in one point. If $b > 0$ then the pair of electrons is between nucleus and valence electron, in case $b < 0$ the nucleus is between valence and pair electrons. Experimental and fitted transition energy in eV, the data are from NIST tables [7], are in following table

n,l	calculated	exp
3,0	3.373209	3.373129
3,1	3.834250	3.834258
4,0	4.340903	4.340942
4,1	4.521672	4.521648
4,2	4.540778	4.540720
5,0	4.748581	4.748533
5,1	4.837294	4.837313
5,2	4.847048	4.847153
5,3	4.850979	4.84833
6,0	4.957902	4.957835
6,1	5.007840	5.007826
6,2	5.013473	5.013587
7,0	5.079451	5.07937
7,1	5.110292	5.110300
7,2	5.113834	5.11391
8,0	5.156239	5.15614
8,1	5.176603	5.176542
8,2	5.178973	5.17898
9,0	5.207825	5.20775
9,1	5.221969	5.222000
9,2	5.223632	5.22362
10,0	5.156239	5.15614
10,1	5.254363	5.254346
10,2	5.255746	5.2556

11,0	5.270671	5.2706
11,1	5.278298	5.27790
11,2	5.279208	5.2790
12,1	5.296482	5.296498
12,2	5.297182	5.2972
13,1	5.310619	5.310605
14,1	5.321828	5.321822
15,1	5.330863	5.330764
16,1	5.338254	5.338181
17,1	5.344375	5.344391
18,1	5.349503	5.349541
19,1	5.353840	5.353865
20,1	5.357542	5.357529
21,1	5.390727	5.360724
22,1	5.363486	5.363449
26,1	5.365893	5.365907
27,1	5.372990	5.373028
28,1	5.374306	5.374267
29,1	5.375488	5.375323
30,1	5.376554	5.376417
31,1	5.377518	5.377450
32,1	5.378393	5.378225
33,1	5.379118	5.37904
34,1	5.379917	5.37971
35,1	5.380582	5.38034
36,1	5.381193	5.38098
37,1	5.381755	5.38150
38,1	5.382273	5.38198
39,1	5.382752	5.38245
40,1	5.383195	5.38301
41,1	5.383607	5.37351
42,1	5.383959	5.38399
limit	5.3917291	5.3917191

If the fit to do with natural expression for transition energy

$$\varepsilon_{tr} = \varepsilon(n = 2, l = 0) - \varepsilon(n, l = 0)$$

the result become worse. Why this happens is unclear, because of many

reason for this can be found. Binding energy of ground state is

$$\varepsilon_0 = V_0 + 5.37083\ eV$$

while today measured ionization energy is 5.3917 eV. So a principal situation is possible when the valence electron is in area of continual spectra but the atom is still stable if the temperature of surround medium is enough low. In my opinion this possible effect deserves experimental efforts.

In any case here is good deal of theoretical work. Even students can be involved in job, the flat type of education system is well for some limit.

5 Fluid as mechanical field

5.1 Introduction

Here the word 'fluid' means a continual isotropic homogeneous mechanical medium.

In mechanics, the description of continual states is grounded on Newtonian lows. At this approach from impulse conservation low and phenomenological properties of a system the Navier-Stokes equations are constructed. Such method extends the particle dynamics in area of field objects.

Besides, the fluid regard as a field of mechanical shifts and the lagrangian formalism employ as framework of fluid dynamics, [5] and [6]. The lagrangian formalism is general method for description of any field. However, when this method is taken for description of mechanical continual system then the main property of any field lose of the sight. The property is the spreading of internal interaction in any field from point to point with finite velocity.

Internal mechanical interactions in a fluid are transmitting with velocity of sound. This property is bringing into play if the Lorentz, not Galileo, transformations with parameter c, which is the velocity of sound in fluid, are employed for coordinate system changes. In this article such road is chosen for description of the fluid.

The Clifford algebra, [3][11][12], with standard lagrangian formalism take as tool for delineation the dynamics of fluid. The short review of Clifford algebra properties is in the end of the article. The choice of Clifford's formalism is forced by situation in high energy physics where for description of fermions the space-time assumed, however implicitly, to be the Clifford algebra but for description of the bosons the space-time is taken as vector variety. This is hard for comprehension. Because the algebra contain the vector space it seems more consistently put into use the Clifford algebra anywhere, including the mechanical systems.

For going in this way the some mixture of Euler and Lagrange variables is convenient. If in point $\vec{x}$ at time t is the particle, which at time t_0 was in point $\vec{x}_0$, then three-vector of mechanical shift $\vec{\xi}(t,\vec{x}) = \vec{x} - \vec{x}_0(t,\vec{x})$ together with quantity $\xi_0 = c(t - t_0(t,\vec{x}))$ regard as the space and time parts of the shift four vector $\xi(x)$

More detailing this looks as

$$\xi = \xi_0\gamma_0 + \xi_n\gamma_n$$

$$x = x_0\gamma_0 + x_n\gamma_n$$

$$x\gamma_0 = x_0 + \vec{x}$$

$$\xi\gamma_0 = \xi_0 + \vec{\xi}$$

When absolute time is taking - this is usual representation for mechanical systems because the fundamental interactions are transmitting with velocity of light - then the time is independent upon the space points and time's part of the shift four vector becomes known (taking for simplicity $t_0 = 0$)

$$\xi_0 = ct$$

The space variety also becomes absolute in this case. Due to existence of fundamental interactions the relative velocities in fluid may exceed the velocity of sound. Of course, they always are less of light velocity.

5.2 Fluid parameters

It is well approach regard any mechanical system as variety of particles. The interaction between particles is so small that the ones are on mass shell and each particle move on trajectory $x(s)$. The tangent four vector, $u(s)$, to trajectory of the particle which has the mass M and four impulse P is

$$P = Mu$$

$$u = \frac{dx}{ds}$$

$$u\gamma_0 = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}(1+\frac{\vec{v}}{c})$$

For continual state it needs to put $M = \rho d^3x$ where ρ is the density of the mass and d^3x is small volume. Then two independent parameters exist. These are the four scalar $m = \rho\sqrt{1-v^2/c^2}$ and the four vector of the mass flow J_m

$$J_m\gamma_0 = \rho(1+\frac{\vec{v}}{c})$$

In mechanical interactions the mass is conserving quantity so

$$\partial_t\rho + \overrightarrow{\nabla}\cdot(\rho\vec{v}) = 0$$

Other set of parameters is the relative shifts (these are the deformations), which in local limit are following

$$\nabla\xi = s + f$$

$$s = \nabla\cdot\xi = \partial_0\xi_0 + \overrightarrow{\nabla}\cdot\vec{\xi}$$

$$f = \nabla\wedge\xi = -\partial_0\vec{\xi} - \overrightarrow{\nabla}\xi_0 + i_c\overrightarrow{\nabla}\times\vec{\xi}$$

where $c\partial_0 = \partial_t$ and all matrices are four-dimensional.

In case of absolute time the deformations are following

$$s = 1 + \overrightarrow{\nabla}\cdot\vec{\xi}$$

$$f = -\frac{\vec{v}}{c} + i_c\vec{h}$$

$$\vec{h} = \overrightarrow{\nabla}\times\vec{\xi}$$

where $\vec{v}$ is the local velocity of fluid, all matrices are four-dimensional.

If not relativistic formalism is using then

$$\overrightarrow{\nabla}\vec{\xi} = \overrightarrow{\nabla}\cdot\vec{\xi} + i\vec{h}$$

where all matrices are two-dimensional. Hence the appearance of the pseudovector $\vec{h} = \overrightarrow{\nabla}\times\vec{\xi}$ as a part of deformations is inevitable in field model of

a fluid. As standard in usual model of fluid the variable $\overrightarrow{\nabla} \times \vec{v}$ is taking for one of parameters.

The deformations are field quantities. They are pure mathematical but not physical objects. In other words, these parameters do not exist in nature. It is because $m\xi$ but not ξ itself may exists as real quantity. We get out these variables with goal to make the construction of fluid lagrangian more evident.

Remark, the coincidence of parameter $\vec{v}$ for both $\nabla\xi$ and u fields permit do not count the shadow w-field separately.

The speed of fundamental interactions spreading is equal to velocity of light. Hence the snapshot of stream can be done and the picture of current lines will be appearing. On a line of current the interval is space-like and so the tangent three-vector for a line is unite pseudovector $i\vec{v}/v$. For simplicity below the existence of such additional parameter is ignored. Remark that in work of a soviet physics near 1972 year a unit vector was introduced as an external parameter for description of solid state.

5.3 Lagrangian of the fluid

The lagrangian of a single field can be written as sum of the free field lagrangian and the self-interaction lagrangian

$$L = L_0 + L_{sint}$$

Here L_0 is the lagrangian of free field. This means that external and self-interaction forces are switching off. The lagrangian of free fundamental field is the square form of field tensions (if the ones disappear on infinity)

$$L_0 = kF^2$$

$$k = \ constant$$

For fluid the condition of internal forces decreasing when the distances increase is valid. From Hook low the fluid tensions are linear functions from deformations. However, in fluid the parameter k is not constant. Indeed, this parameter has the dimension of energy density. Because self-interaction is switching out only the quantity $mc^2 = c^2\rho\sqrt{1 - v^2/c^2}$ has required dimension. And from Bohr correspondence principle - this is the one of general physical principles - it needs to take $k \sim c^2\rho$. Hence for fluid the lagrangian of free field (in Hook's low area) is following

$$L_0 = \frac{1}{2}mc^2\overline{\nabla(s+f)}\nabla(s+f) = \frac{1}{2}mc^2(s^2 - f^2)$$

$$\nabla = \frac{1}{c}\gamma_0\partial_t - \gamma_n\partial_n; \quad \nabla\gamma_0 = \frac{1}{c}\partial_t - \overrightarrow{\nabla}$$

Not mechanical interaction created the mass of fluid so, because of Lorentz invariance, the quantity m is external parameter. Also $m\xi$ is entire quantity and, foregoing, the fluid motion is independent upon the shifts directly. From these reasons m is not variable by shift four vector and so m is considering as a function of space-time point, $m = m(x)$, not as function of deformations, $m \neq m(\xi)$. This simplification is the example of coherence condition usage. Correspondingly, the four dimensional equation for ideal fluid is

$$\nabla\left[mc^2(s+f)\right] = 0$$

Because the parameters $s,\ f$ are taken with equal coefficients the compression modulus is equal to $1/(c^2\rho)$, this is not in bad agreement with data and so acceptable for first approach.

In any case the self-interaction lagrangian can be written as

$$L_{sint} = \xi \cdot J$$

where four vector J is not variable quantity. By physical meaning this four vector represent the self-interaction forces in fluid. As norm for fluid the ones do not depend directly upon shifts and so $J \sim J_m$. From physical reasons these forces disappear when $f \to 0$ even if the pressure is not equal to zero. Correspondingly,

$$J \sim fJ_m$$

or, more widely,

$$J = af \cdot J_m + bf \wedge J_m$$

In this way the equation of fluid dynamics in four dimension form is

$$\nabla\left[mc^2(s+f)\right] = af \cdot J_m + bf \wedge J_m$$

Unknown scalar functions $a,\ b$ depend on the deformations and have the dimension of acceleration. Below for simplicity it is assuming that these functions are equal to constants. As with the compression modulus it is possible to take, as more symmetrical for first approach, $b = -a$

Two essential differences with standard approach are here.

In any field theory both the time and the space derivatives appear symmetrically, in usual model of a fluid the degree of the ones differ.

The parameter $k = mc^2$ is not constant and so the pseudo-four-vector part of field equation in general case is not zero as it is must be for fundamental

fields. For example and comparison, the lagrangian of free electromagnetic field contains the pseudoscalar term $\vec{E} \cdot \vec{H}$. It has no matter is $\vec{E} \cdot \vec{H}$ equal to zero or not, this part of lagrangian create the pseudo-four-vector dynamical equation. However, the one coincide with kinematic restrictions $\overrightarrow{\nabla} \cdot \vec{H} = 0$, $\partial_t \vec{H} + \overrightarrow{\nabla} \times \vec{E} = 0$. For fluid, because of $m = m(x)$, the kinematic and the dynamical pseudo-four-vector equations do not coincide. In a field models the invariance of lagrangian at time and space inversions are jointed so the whole pseudovector part of the lagrangian may be equal to zero what bring some kinematic restrictions for shifts.

5.4 Equations of the stream

For going to three-dimension equations of motion it needs to take the absolute time, then multiply the basic equation on matrix γ_0 and put together the terms with equal O3 properties. It is conveniently denominate

$$p_c = -c^2 m(1 + \overrightarrow{\nabla} \cdot \vec{\xi}) = (p - c^2\rho)\sqrt{1 - \frac{v^2}{c^2}}$$

where the note of hydrostatic pressure, p, is clear. In result the equations of stream have following form

$$\partial_t p_c + c^2 \overrightarrow{\nabla} \cdot (m\vec{v}) = \frac{a}{c}\rho v^2$$

$$\partial_t (m\vec{v}) + \overrightarrow{\nabla} p_c + c^2 \overrightarrow{\nabla} \times (m\vec{h}) = -\frac{a}{c}\rho(\vec{v} + \vec{h} \times \vec{v})$$

$$\overrightarrow{\nabla} \cdot (m\vec{h}) = -\frac{b}{c^3}\rho\vec{v} \cdot \vec{h}$$

$$\partial_t (m\vec{h}) - \overrightarrow{\nabla} \times (m\vec{v}) = \frac{b}{c}\rho\vec{h}$$

$$m = \rho\sqrt{1 - \frac{v^2}{c^2}}$$

Below the velocity of sound take for unit of speed. From Le Chatelier principle the constant a is positive and the constant b is negative numbers. Usual boundary conditions are valid with one supplement. Because any mass move

with finite speed the singular solutions for velocity must be rejected. For example, if the axial symmetrical stream has singularity $v = q\, ln(\sqrt{x^2 + y^2})$ with q=constant then self-energy of this state is finite but because at small distances the velocity growth to infinity we must put q=0.

The elimination of unusual parameter $\vec{h}$ from equations of stream is possible. Using both kinematic

$$\overrightarrow{\nabla} \cdot \vec{h} = 0; \quad \partial_t \vec{h} - \overrightarrow{\nabla} \times \vec{v} = 0;$$

and dynamical pseudoscalar and pseudovector equations, we get the following connection between $\vec{h}$ and the usual variables of fluid dynamics

$$\vec{h}(b\rho - \partial_t m) = \vec{v} \times \overrightarrow{\nabla} m$$

Consequently, the vicinities of points

$$\partial_t \left(\rho\sqrt{1 - v^2}\right) = b\rho$$

regularly are the regions of unstable flow.

After the pseudovector $\vec{h}$ excluding the equation system contains only usual quantities and is closed. However, reduced system is closed only formally, in general case the compatibility of its solutions with kinematic restrictions for pseudovector $\vec{h}$ needs to check. Or another restriction for extra equations elimination brings into being.

Other essential difference with usual model is that in general case a stream is not continual. When velocity of stream reach the value of the sound velocity then the phase of quantity m is changing

$$\rho\sqrt{1 - v^2} \to i\rho\sqrt{v^2 - 1}$$

and we are going in area which is space-like for mechanical but time-like for fundamental interactions. For example, the three-vector equation in space-like area is

$$\partial_t(m\vec{h}) - \overrightarrow{\nabla} \times (m\vec{v}) = -a\rho(\vec{v} + \vec{h} \times \vec{v})$$

Both intuitively and formally, this is abeyance area because here is the solution $f = 0$ which is trivial for usual zone but unexpected for space-like area.

The mass conservation low is valid anywhere if the relative velocities in stream are less essentially of light velocity. Remark once again, the density of mass is external parameter.

Because here the sound velocity always is the constant it is somewhat unusual thermodynamic situation, nevertheless, it is real in many cases. Not

thermodynamic but field approach was using, however, the scalar equation after integration gives the thermodynamic connection.

The $m\xi$, not ξ itself, exist in nature so initially the $m\xi$ needs take as potential of mechanical field. Nevertheless, because of mass conservation low, it is possible the dividing of the mass from other variables.

Of course, this is the simplest field model of fluid.

For example regard few streams. Only the short equation system, because of its formal fullness, is using.

5.5 Ideal fluid

In this case all internal interactions ignored and the equations for extended pressure p_c and impulse $m\vec{v}$ are isolated wave equations

$$(\partial_t^2 - \Delta)p_c = 0$$

$$(\partial_t^2 - \Delta)m\vec{v} = 0$$

Elementary motion is the stationary stream of uncompressed fluid restricted by two sheets with gap $x = [0, L]$. For geometry

$$\vec{v} = v(x)\vec{e}_z$$

and with boundary conditions $v(0) = 0;\ v(x_1) = v_1$ the velocity of stream is

$$v^2 = \frac{c^2}{2}\left(1 - \sqrt{1 - k^2x^2}\right)$$

Such flow is possible if the integration constant k is small, $kL < 1$. Moreover, the stream becomes unstable if the velocity v_1 is big enough. Indeed, if the forces are absent the motion of a particle on straight line is going with zero acceleration, the similar motion of ideal fluid take place with zero gradient of pressure along the velocity direction. Then the pressure in this flow has no the explicit dependence on space point, it is

$$p = c^2\rho + q\frac{c^2\rho}{\sqrt{1 - v^2/c^2}}$$

where, because from data in any fluid $p < c^2\rho$, the integration constant q is less of zero. (The discrepancy with Bernoulli low is caused by simple expression for compression modulus). Correspondingly, for big velocities the pressure becomes negative that means the instability of flow. These properties of simplest stream are similar to the ones of the plane Couette flow, however the last is being for not ideal fluid.

For pipe stream the situation is similar so sometimes the coaxial but not simple tubing will be best for a fluid moving.

In case of the stream with geometry

$$\vec{v} = v(x_\perp)\vec{e}_\varphi; \quad \vec{x}_\perp \cdot \vec{e}_\varphi = 0$$

which stands, for example, to different rotations in atmosphere, the solutions are:

or

$$v = 0,$$

or

$$v\sqrt{1-v^2} = Ax_\perp + \frac{B}{x_\perp}$$

Correspondingly, in general case as the cyclones as the anticyclones are concentrated, due to constrain $v < c$, in the some finite areas, out of the ones the fluid is or immovable or there is the whirl in whirl structure of flow.

Ideal fluid is the first face of the any. At least qualitatively, the consideration of this system reveals the main features of real fluids. So it is possible to expect the emergence as h, they are created by accelerations, as v, they become due to interaction spreading finiteness, singularities in the streams. Because $f = -\vec{v} + i\vec{h}$ it is questionably that the approximation of $a,\ b$ functions by means of constants is valid for unstable stream.

In Newtonian mechanics any interaction spread with infinite velocity and it is well approach if the relative speed of the particles is more less of light velocity. But in fluid dynamics certainly it needs take into account the field conception on point to point spreading of the mechanical interaction with velocity of sound. This may be make up using the field theory tools as it is done in this article, or using the methods of relativistic mechanics, or by other way, but this needs doing.

6 Potentials of pionic field

6.1 Extended Yukawa potential

Here the classical potential of pionic field is constructed using the usual lagrangian formalism.

In a nucleus the nucleons are near mass shell. Then in low energy area it is possible to regard the nucleon as moving in potential well which is generated by cloud of virtual particles. The pions give the main contribution to

interaction of a nucleon with cloud of virtual mesons. Correspondingly, the pionic field is the main part of strong interaction in nuclei. Simplest potential of pionic field is the Yukawa potential

$$p(R) \sim \frac{1}{R} exp(-mR)$$

where m is the mass of free pion.

Both from experiment and from theory this potential is not valid on small distances. From data the nuclear forces do not grow in center of field. In theory the self-energy of any field must be finite. Correspondingly, at phenomenological description of the nucleus not Yukawa but phenomenological potentials of Woods-Saxon, or Bonn-Paris, or other types are using.

An extension of Yukawa potential to area of small distances is desirable. This is possible to do just as it was made in previous section with potential of electromagnetic field.

The first step is the regarding of virtual particles cloud in a nucleus as a continual state. Then in general case the additional parameter, $u(x)$, exists, by physical meaning it is the local four velocity of virtual medium. The pion in cloud is far off mass shall and for moving a pion in free space it needs to spend the energy no less of mc^2. Therefore, for pionic cloud $u^2 < 0$. Of course, this condition can be valid in many other cases. This cloud of virtual pions form the pionic field in nucleus. Pionic field have two local parameters, the potential and four velocity, which both are essential for description of the field.

The next step is the consideration of four velocity itself as potential of some field, w-field, which was introduced in subsection 'Foundation'. The virtual inertial forces of w-field will prevent tightening of pionic cloud and nucleus in a point with infinite self-energy.

For quantitative description of virtual pionic cloud in classical physics it is need to build the lagrangian of field. On this stage the main builder's requirements is: independently of the nature of a field the 'jet', it is the quantity

$$j = \delta L_{int}/\delta\varphi,$$

must be the linear function of four velocity. The pion is pseudoscalar isovector particle and so the pionic field has these properties. Simplest lagrangian of pionic field with its shadow w-field take as following (always using Clifford algebra, [3][11][12])

$$L \sim \frac{1}{2}(\nabla p)^2 + \frac{k^2}{2}(\nabla u)^2 + \frac{g_1}{2}p^2 + g_2 p(u \cdot \nabla)p$$

$$\nabla = \gamma_0 \partial_0 - \gamma_n \partial_n$$

Where the first and second terms are the lagrangians of free pionic and free w-fields. Today for usual interactions the square form of the ones is almost axiom.

Third term is simplest self-interaction lagrangian for pionic field. It is widely known and used. However, as it was seeing in example of Coulomb field, it is possible that on infinity the potential of pionic field is not equal to zero.

Last term is simplest lagrangian for interaction between pionic and w-field. Such form of the one is possible because, being the term of lagrangian, the quantity $\nabla \cdot (up^2)$ effectively is equal to zero. Remark that we neglect by possible term in lagrangian $\sim u^2$ because the self-interaction of w-field, at least in area of small energies, looks too exotic.

The variation of the lagrangian is following

$$\begin{aligned}\delta L \sim &(\nabla p)(\nabla \delta p) + k^2 (\nabla u)(\nabla \delta u) + g_1 p \delta p + \\ &+ g_2 \delta p (u \cdot \nabla) p + g_2 p (\delta u \cdot \nabla) p + g_2 p (u \cdot \nabla) \delta p\end{aligned}$$

Using the standard way of variation formalism we get the field equations in form

$$\nabla^2 p = g_1 p - g_2 p \nabla \cdot u$$

$$k^2 \nabla^2 u = \frac{g_2}{2} \nabla p^2$$

For static spherical symmetrical field

$$p = p(R), \; u\gamma_0 = u(R)\vec{e}_R$$

and after velocity parameter excluding the equation for pionic potential is

$$p'' + \frac{2}{R} p' = -g_1 p + c_1 p^3$$

With boundary condition $p(0) = 0$ the equation in area of small distances has no analytical solutions and we reject this equation.

Due to coherence condition here exist other solutions of variation task. The solution similar to Glauber state is following (for velocity the equation is without changing)

$$\nabla^2 p = g_1 p + g_2 (u \cdot \nabla) p$$

with restriction on interaction constants in form (coherence condition)

$$\int p(u\cdot\nabla)\delta p d^4x = 0$$

where all function after interaction sign are the solutions of upper system of differential equations. So

$$\delta p = \frac{\partial p}{\partial c_n}\delta c_n$$

where c_n are the constants of integration. If the ones are fixed numbers ('charges') then coherence condition is automatically fulfill. For simplicity below this type of coherence condition is using.

In this case the equations for static spherical symmetrical field are following

$$p'' + \frac{2}{R}p' = -g_1 p - g_2 u p'$$

$$u' + \frac{2}{R}u = cp^2$$

In lower equation we take into account that the self-energy of any field is finite and for simplicity the pionic potential is chosen vanishing on infinity. After the velocity parameter excluding the equation for pionic potential become following

$$p'' + \frac{2}{R}p' = -g_1 p + \frac{p'}{R^2}\Big(s_1 + s_2\int_0^R (p^2 - p_\infty^2)R^2 dR\Big)$$

Now the linear equation has physical solution at small distances. From physical reason at approximate searching of pionic potential it is natural the usage of free field potential as first input. For free pionic field the potential is

$$p_f = k_1 + \frac{k_2}{R}$$

Once again, the self-energy of any field must be finite so the last integration constant take equal to zero.

In this way the approximate equation for potential of pionic field is following

$$p'' + \frac{2}{R}p' = -g_1 p + p'(\frac{c_1}{R^2} + c_2 R)$$

with solution

$$p \sim exp(-\frac{a}{R} + \frac{g_1}{6}R^2)$$

At first look the constant g_1 determine the behavior of potential on infinity, at small distances the constant a, which is the scale of free w-field, set up

the activity of potential. This is the potential well but it is imaginary well because the pionic field is pseudoscalar field. It is simply visible when the Clifford algebra [12] is using. In this case the coordinate vectors are the Pauli matrices. In space algebra the matrix

$$\vec{e}_1\vec{e}_2\vec{e}_3 = i1$$

change sign at parity transformation. Hence the imaginary unit of the complex numbers algebra at that time can be considered as the pseudoscalar of space algebra.

Remark that in space-time Clifford algebra the two pseudoscalars exist (or two different imaginary units if we wish). Then in general case the pionic potential is the mixture of usual $\sim i$ and chiral $\sim i_c$ pseudoscalars.

This extended Yukawa potential may be useful in area of low energy nuclear physics.

6.2 Shell model for mirror light nuclei

For all days of nuclear physics the structure of nuclei is the interesting question [19], for light nuclei the last theoretical results are in [20] and [21]. The base of usual models is: the nucleon-nucleon potential, which gets fitting the NN scattering data; the solution of many-body Schrodinger equation. In this section both these essences are rounded applying the extensions of Yukawa and Coulomb potentials together with the potential of vacuum gluonic field.

Let us regard the simplest shell model (the point-like nucleon move in classical field) using nonlinear potentials.

Following fields, in order of their assumed weights, act in nucleus: pionic, gluonic, electrostatic and w-field.

The w-field was taken in the space-like form, $u(x)^2 < 0$, and in vacuum state so this field does not interact with electrostatic and gluonic fields because the ones are time-like fields, $A(x)^2 > 0, G(x)^2 > 0$. The function of w-field is the modification of pionic potential. It is possible that the w-field act directly on nucleon, the example of such interaction is in subsection 4.6, for first approach this effect is missing. Because in general case all components of a four vector are presented such decoupling of fields is valid as first approach only.

Consequently, the electrostatic field is in free state and the potential energy of a proton in this field is

$$V_c = \alpha\frac{Z-1}{2R}$$

This potential in area of small distances is not physical but, because of asymptotic boundary conditions usage, this has no matter.

Similarly, gluonic field is in free state (more details about this field are in section 7) with potential

$$\varphi_g = c_1 + c_2 R$$

For in-nucleus interaction between the nucleons we put the charge of gluonic field equal to zero, $c_2 = 0$. Therefore, the respective contribution of gluonic field in binding energy is constant and the potentials of vacuum, for gluonic field the constant c_1, are observable numbers. The lagrangian of gluonic field is not quadratic form hence the superposition principle is not valid for this field. For first approach the corresponding addition to binding energy of the nucleon take almost identical for all light nuclei.

Among acting on the nucleon in nucleus forces the pionic ones are biggest. All new features of extended pionic potential are generating by free w-field. From this reason let us switch off the self-interaction of pionic field and put $g_1 = 0$. This does not mean that the mass of a pion is zero because in this model any particle is not local field object which has not zero size and so the mass of a particle is the integral from tensions and potentials of fields. Switching off the pure self-interaction of pionic field contradict to common approach but it has hard physical ground because the pure field self-interaction and third Newtonian low (the impulse conservation low) are not in harmony. In this case for pionic potential the exact vacuum solutions exist

$$p \equiv constant,\ R^2 u \equiv constant$$

and in low energy area the not constant part of pionic potential can be regarded as small perturbation of vacuum potential. On whole R-axis that always will be true. Pionic potential is considered as pure chiral pseudoscalar, for simplicity it is restricted by condition $p(0) = 0$. After these simplifications the potential of pionic field is

$$p = i_c\, \vec{\tau} g\, exp(-\frac{a}{R})$$

More than hundred years ago was recognized that a particle does not interact with other particles in a system but interact with the fields. Therefore, the pionic field is possible to regard as external field. Obviously, it is well approximation due to small proton-neutron mass difference. On big distances the behavior of pionic potential is similar to Coulomb field. On small distances the potential quickly disappears. This means that pionic forces act only on the nucleons which are near surface $R = a$. In other words, these are

the surfacing forces. Are these forces of finite or long range as well as contain they repulsive forces or not is the matter of a convention. The parameters of pionic field depend upon the neutron and proton numbers in nucleus. For simplicity below mirror nuclei are considering, they contain equal number of protons and neutrons. For mirror nucleus the electric charge, Z, and the number of nucleons, A, are connecting as $2Z = A$. In this case the simplest approach for surfacing forces is

$$a \sim (A-1)^{2/3}$$

with may be additional slow dependence on mass number. Let us hold of the simplest kinematic multiplier and put

$$Ga = k\frac{(A-1)}{A}(A-1)^{2/3} \qquad k = constant$$

By physical meaning the parameter Ga is the dimensionless charge of pionic field. In this way we take into account the essential properties of pionic field generated by free w-field and avoid the face of many-body problem.

For both the proton and neutron the space-time dependence of wave functions is identical if the electromagnetic interaction eliminate.

The Dirac equation initially was grounded on Clifford algebra and for inclusion of interaction between the fermion and a field which has any algebraic structure the problems did not appear. The equation for wave function of nucleon in pionic field is following

$$(i\nabla - i_c V)\Psi = M\Psi$$

$$V = Gexp(-\frac{a}{R})$$

$$2Z = A, \hbar = 1, c = 1$$

For stationary states with energy E the equation for upper part of wave function is

$$(\Delta + V'\vec{e}_R)\Psi_{up} = (M^2 - E^2 + V^2)\Psi_{up}$$

Obviously, this wave function is not simple factorizing term, it is the sum of two terms with different algebraic structure and differential equations for radial parts of wave function have forth order. By physical meaning the term $V'\vec{e}_R$ represent the spin-orbital interaction and from data the one may be discarded for light nuclei.

After discarding by spin-orbital interaction and including the gluonic and electrostatic forces the Dirac equation for logarithmic derivative of nucleon radial wave function is

$$f' + f^2 + \frac{2}{R}f = \frac{l(l+1)}{R^2} + M^2 - (E - V_g)^2 + 2MV_c + V_p^2$$

where: $M = 938\,MeV$ and E is the energy of nucleon in nucleus; V_g, V_c, V_p are the potential energies of nucleon in vacuum gluonic, electrostatic and pionic fields of nucleus.

For free motion of nucleon its energy is: in empty space $E_{free} = M$, while in pionic field, running the constant a to zero, $E_{free}^2 = M^2 + G^2$. Correspondingly, the binding energy of a nucleon in this field determinate as

$$\varepsilon = \sqrt{M^2 + G^2} - E,\ \varepsilon > 0$$

Nuclear physics has some problems with description of electrostatic interaction. We have no doubts that instability of heavy nuclei is produced by electromagnetic interaction between protons. If for description of this interaction the Coulomb potential, $V_c = \alpha(Z-1)/R$, is selected then the area of stable nuclei is far beyond of Mendeleev table. Because this property holds in all models the some modifications of electrostatic potential needs. Typically the potential of charged sphere regard as suitable for heavy nuclei. In nonlinear model the situation with Coulombian interaction is almost the same. Because the extended Yukawa potential quickly disappears on small distances the motion of nucleons in internal area of pionic field is almost the free motion. Correspondingly, the electrostatic interaction gathers the protons near a surface, $R = R_0$. Probing particle, it is a proton itself, being in internal area of pionic field does not feel the electric charge. The difference with usual model is that this property holds for any mirror nuclei. We will treat this circumstance as strong polarizability of pionic field; in this case the main part of electrostatic field is suppressed in all area of pionic field that is the whole nucleus. For description of this property the nonlinear electrostatic potential decompose in $1/(R - R_0)$ series (as if it has been the plasma) and hold two main terms. Namely,

$$V_c = c_1\alpha\frac{(Z-1)}{R - R_0} - c_2\frac{a(Z-1)}{(R - R_0)^2}$$

where $0 < c_1 \ll 1$ and $c_2 > 0$ are unknown constants.

Because R_0 is the one of wave function knots the asymptotic procedure for equation solving will involve the additional equation so we prefer to use the

usual approach. For this reason below the pionic potential approximate as

$$V_p^2 = G^2\big(1 - 2\frac{a}{R} + 2\frac{a^2}{R^2}\big)$$

and so the corrections to energies of states with knots of wave function $N \neq 0$ are missing.

For vacuum potential of gluonic field the independence upon mass number was assumed. However, because the deuteron is special case we take

$$V_g = -2d\frac{(A-1)}{A}$$

where d is unknown constant.

Renominating the some constants (because A is the mass number) the wave function take as

$$f = B + \frac{D}{R} + \frac{K}{R-R_0} + \sum \frac{1}{R-R_n}$$

$$\Psi \sim R^D(R-R_0)^K \prod (R-R_n) exp(BR)$$

As result the energy of a proton (for neutron needs to put or $K = 0$ or $Z = 1$) in a nucleus is

$$\varepsilon = -2d\frac{(A-1)}{A} - m_{ef}\Big[1 - \sqrt{1 - G^4a^2/(m_{ef}n_{ef})^2}\,\Big]$$

$$m_{ef} = \sqrt{M^2 + G^2}$$

$$n_{ef} = D + N + 1 + K$$

$$D = -0.5 + \sqrt{(l+0.5)^2 + 2G^2a^2}$$

$$K = 0.5\Big[1 - \sqrt{1 - 0.0035(Z-1)Ga}\,\Big]$$

where N is the number of wave function zeros. To avoid the searching of nonworking constants and because of in-nuclei quantities we are interesting for, the constant $c_1 \to 0$, however, hold c_2. Taking into account that the last known mirror nucleus is 80Zr the value 0.0035 was found by manual. It has small influence on the value of basic unknown parameters, nonlinear part of electrostatic interaction is holding because it is interesting that not

main part of electrostatic potential produce the instability of nuclei and this is compatible with T-invariance.

The expression for nucleon energy regard as exact, because the nuclei structure is unknown not the minimization procedure but the three points for calibration of unknown constants are choosing. The ones are: the binding energies of the deuteron, [2.224], and alpha particle, [28.284] with condition, because of absence as excitations as resonances in deuteron, that gluonic field subtraction is exactly equal to binding energy of nucleon in p=1, n=1 pionic field for (0,1) state.

This calibration gives following values of unknown parameters:

$$G = 302.316\, MeV;\ k = 0.3908,\ d = 0.4317\ MeV;$$

For simplicity, the mirror nuclei regard as being built up from virtual alpha particles and deuterons. Correspondingly, the energies of pn pair are calculated only.

Below all energies are in MeV; calculating quantities are in blue while measured in black color, sometimes the last are in square brackets also. The data was taken from [8].

As in any model with spherical symmetrical potential without spin-orbital interaction the nucleon energy depends upon number of wave function zeros, N, and orbital momentum, l. The states may be numerated as (N, l). It is quit noticeable that changing of zeros number create bigger shift of levels than changing of orbital momentum. This means that quantity N but not N+l+constant is preferable as main quantum number of levels what create some troubles with choice of shells order. Along (N,l) numbers the typical hierarchy of levels is following: (0,0); (0,1), (1,0); (0,2), (1,1), (2,0); (0,3), (1,2), (2,1), (3,0); etc.

Additionally, let us pair off the nuclei:

$$^{2}H,^{4}He;\ \ ^{6}Li,^{8}Be;\ \ ^{10}B,^{12}C;\ \ ^{14}N,^{16}O;\ \ etc$$

In any pair the first nucleus has unpaired nucleons. From data at passing from last nucleus in pair to first nucleus in next pair the binding energy per nucleon downfall. In any shell model this means that the new shell or subshell is opening at going from pair to pair. Or may be the change of subshell filling does occur.

Spin-orbital interaction is discarded.

6.2.1 Binding energies and spectra

$4He$

Binding energies of pn pair in alpha particle are following

state	energy	range
0,0	14.143	-
0,1	5.642	-
1,0	4.235	-
0,2	2.188	-
1,1	2.006	-
2,0	1.521	-
3av	0.622	-0.13,+0.22
4av	0.020	-0.015,+0.18
3,1	-0.031	-
4,0	-0.158	-

In fourth shell the averaging was made for states with positive energy. Beginning from this shell, because of gluonic subtraction from energy of the nucleon, the states with negative energies appear, namely (3,1), (4,0) and all following states. The cases when each pn pair has negative binding energy are treated as resonances. Because the resonances are placed closely the energies of first fourth of them are calculated.

Minimal observable excitation has 20.21 value and so all nucleons of this nucleus are excited at once. When all nucleons are on the same shell the excitation energies and their assumed connection with data, the ones are in square brackets, are

$$4(0,1) = 17.00\ [absent]$$

$$4(1,0) = 19.82\ [20.21]$$

$$4(0,2) = 23.91\ [23.64]$$

$$4(1,1) = 24.27\ [24.25]$$

$$4(2,0) = 25.24\ [25.21]$$

$$4(3av) = 27.04 \ [27.42]$$

$$4(4av) = 28.28 \ [absent]$$

$$4(3,1) = 28.35 \ [28.37]$$

$$4(4,0) = 28.60 \ [28.64]$$

When in (0,1) state is a single pn pair while the second pair is on upper state then only one transition,

$$2(0,1+2,0) = 21.12 \ [21.01],$$

is in correspondence with data. This means at least the partial forbidding of (0,1) state for excitations.

Between other crossed transitions the acceptable are;

$$2(1,0+0,2) = 21.86 \ [21.84]$$

$$2(1,0+3av) = 23.43 \ [23.33]$$

$$2(1,1+3av) = 25.66 \ [25.95]$$

$$2(4av+3,1) = 28.32 \ [28.31]$$

$$2(4av+4,0) = 28.44 \ [28.39]$$

This is acceptable result. The possible forbidding of (0,1) state and the extra possible transitions are the questions. Because of Coulomb-like type of the spectra, the number of extra transitions will be grown at moving along A-line. So some restrictions of the possibilities are necessary. Remark, the non-linearity of electrostatic potential has no direct influence on the energies of alpha particle but not direct it has. The comparisons with usual models failed because in arxiv.org a calculation of 4He spectrum was not found.

$6Li$

Binding energies of pn pairs in 6Li are following

state	energy	range
0,0	21.094	-
0,1	11.883	-
1,0	8.330	-
0,2	6.111	-
1,1	5.371	-
2,0	3.992	-
3av	2.74	-0.5,+0.7
4av	1.41	-0.2,+0.5
5av	0.624	-0.1,+0.3
6av	0.184	-0.03,+0.1
6,0	-0.105	-

In sixth shell the unstable states appear and on this shell the table of energies is interrupted because for today the resonances of this nucleus were not observable. For such levels the structure of the nucleus is: the lower, (0,0), shell is empty, two pn pairs are in (0,1) state and the one pn pair is in (1,0) state. Binding energy of this configuration is

$$4(0,1) + 2(1,0) = 32.1 \text{ [32.0]}$$

For external transitions, out of (1,0) state, let us assume that virtual alpha particle in (0,1) state is excited as whole. In this case the half empty s-state forbid all transitions of two pn pairs from (0,1) state without excitation of (1,0) state. This restriction eliminates the excitations of two pairs and permits the single and triple pair transitions from ground state to uppers, namely

destination states	calculated energies	observable energy
one pair transitions		
2(1,0-0,2)	2.219	2.186
2(0,1-1,0)	3.553	3.562
2(1,0-2,0)	4.338	4.312
2(1,0-3av)	5.59	5.366 5.65
three pair transitions		
4(0,1-1,1)+2(1,0-1,1)	15.98	15.8
4(0,1-2,0)+2(1,0-0,2)	18.00	17.958
4(0,1-3av)+2(1,0-0,2)	20.5	21.5
4(0,1-3av)+2(1,0-3av)	23.9	23.2
4(0,1-3av)+2(1,0-4av)	25.2	24.779 24.890
4(0,1-4av)+2(1,0-4av)	27.8	26.59
4(0,1-6av)+2(1,0-6av)	31.5	31

However, the things did not have to be so simple as the table shown. By physical meaning the second transition, (0,1)-(1,0), can be regarded as passage of the nucleus to isomeric state. Observable small width of this transition, 8.2 eV, confirms such viewing. Empty (0,0) state means that observable 6Li with this structure can being the isomeric state. It is possible that lower isomeric states of lithium exist. From history of first thermonuclear bombs production, printed and open to any, we known that at testing of first soviet bomb the realized energy was much more less of expected. After adding the lithium shell the energetic of second test become big. If this is not the disinformation then it is strange. In my opinion, the experimental and theoretical efforts need for situation clarifying.

On the whole the results are acceptable.

$8Be$

This nucleus was not found in nature, it is unstable. First few energy levels of pn pair in 8Be are

state	energy
0,0	25.177
0,1	16.815
1,0	11.545
0,2	9.951
1,1	8.459
2,0	6.212
0,3	5.924

Because of 6Li structure, natural configuration of ground state is: (0,0) state is empty; each of (0,1) and (1,0) states contain two pn pairs. For this configuration the binding energy of 8Be is

$$4(0,1) + 4(1,0) = 56.72 \text{ [56.5]}$$

Small, 0.2 MeV, discrepancy with data means the stability of 8Be. Nonlinear electrostatic field is still small and cannot destroy the ground state of this nucleus. In this model, or counting of $N \neq 0$ states energy without usage of asymptotic procedure, or missing additional slow dependence of gluonic subtraction upon mass number are the sources of stable 8Be emerging.

8Be can be regarding as consisting of two virtual alpha particles, however, permitting the destroying of (0,1) state even for lower transitions. As for 6Li the natural restriction on allowed transitions is that the excitation of (0,1) state is possible if the alpha particle in (1,0) state is excited also. In this case the four lower lines are

$$4(1,0-0,2) = 3.19 \text{ [3.03]}$$

$$4(1,0-1,1) + 2(0,1-1,0) = 11.39 \text{ [11.35]}$$

$$4(0,1-1,1) + 4(0,1-1,0) = 16.76 \text{ [16.626]}$$

$$4(1,0-0,2) + 4(0,1-0,2)) = 16.92 \text{ [16.922]}$$

The nearness of third and fourth lines can have different sources. Beginning from 8Be the shells are mixed, however, the first mixings, (3,0)=3.589 and (0,4)=3.594, lay upper. Spin-orbital interaction cannot be the reason because in case of virtual alpha particle transition such splitting is questionable. The chance, as it is printed, can be the reason; the works need to clarify the mechanisms of the lines nearness.

With increasing of mass number the connection of theoretical and observable lines becomes not ambiguous, such 4(1,0-1,1) and 4(1,0-2,0) transitions are or were not observable. So for 8Be as well as for all next nuclei only the first transitions are calculating.

$10B$

The energies of few first levels are below

0,0	27.87
0,1	20.55
1,0	14.098
0,2	13.369
1,1	11.107
0,3	8.576
2,0	8.147
1,2	7.787

The configuration of ground state take with two empty lowest states and half empty (0,2) state

$$4(1,0) + 2(0,2) + 4(1,1) = 63.78 \ [64.75]$$

Here are the configurations which give the best fit of binding energy, however, for spectrum data such choice has preference.

Lower transitions, they have the isomeric nature, are

$$2(1,0-0.2) = 0.73 \ [0.718]$$

$$4(1,0-0.2) = 1.46 \ [1.74]$$

$$2(0.2-1,1) = 2.26 \ [2.154]$$

Remark that in usual models the calculated second transition also is below of measured. For next transitions the abundance of possibilities arise.

The results are acceptable.

$12C$

The energies of few lowest states are

$$(0,0) = 29.78,\ (0,1) = 23.40$$

$$(0,2) = 16.305,\ (1,0) = 16.168,\ (1,1) = 13.347$$

$$(0,3) = 11.050,\ (1,2) = 9.896,\ (2,0) = 9.825,\ (2,1) = 8.337$$

With empty (0,0) and (0,1) states and with virtual alpha particle in each of next three states, the binding energy of 12C is

$$4(0,2) + 4(1,0) + 4(1,1) = 91.64\ [92.16]$$

Because of symmetrical ground state, the little larger number of lower excitations is calculated

$$4(1,1-0,3) = 4.59\ [4.438]$$

$$4((1,1-\overline{1,2;2,0}) = 6.98\ [7.654]$$

$$4(1,1-2,1) = 10.02\ [9.64]$$

$$4(1,0-0,3) = 10.24\ [10.3]$$

$$4(0,2-0,3) = 10.51\ [10.844]$$

Unsatisfactory result for second, [7.654], line can be caused by cut-offing of pionic potential that made to avoid the complicating asymptotic procedure of Dirac equation solution.

Acceptable result it is. Again, the empty lowest states and abundance of possible upper transitions are the questions.

$14N$

The energies of lowest states are

$$(0,0) = 31.22;\ (0,1) = 25.64;\ (0,2) = 18.81$$

$$(1,0) = 17.895;\ (1,1) = 15.262;\ (0,3) = 13.320;\ (1,2) = 11.797$$

$$(2,0) = 11.305\ (2,1) = 9.860\ (0,4) = 9.429$$

From experience with previous nuclei the three lower states is assumed to be empty, the configuration of ground state take as

$$4(1,0) + 4(1,1) + 4(0,3) + 2(1,2) = 104.75\ [104.658]$$

what brings the well value of binding energy. Correspondingly, we expect that the excitations of pn pair from (1,2) state are the lowest transitions. In this case the first four acceptable transitions are:

$$2(1,2-0,4) = 2.368\ [2.312]$$

$$2(1,2-2,2) = 3.933\ [3.948]$$

$$2(1,2-0,5) = 5.052\ [4.915]$$

$$2(1,2-3,1) = 5.104\ [5.105]$$

The transition

$$2(1,1-2,0) = 3.957\ [3.948]$$

is acceptable also. The result for transition energies looks as well while it is bad indeed because many possible excitations were omitted. The absence of spin-orbital splitting is the question also. It seems that simple model reached his boundary. For completeness let us regard the next, 16O nucleus.

$16O$

The energies of lower states are

$$(0,0) = 32.35;\ (0,1) = 27.42;\ (0,2) = 20.96;$$

$$(1,0) = 19.360;\ (1,1) = 16.910;\ (0,3) = 15.377;\ (1,2) = 13.50;$$

$$(2,0) = 12.618;\ (2,1) = 11.227;\ (0,4) = 11.212;$$

If take into account the configuration of 14N ground state and add in (1,2) state the pn pair then binding energy of 16O deviated far of measured energy. The configuration of ground state as

$$4(1,0) + 2(1,1) + 4(0,3) + 6(1,2) = 126.88\ [127.619]$$

suits for binding energy and spectrum but this structure is as for odd-odd nucleus. Because the single pn pairs are presented the spin-orbital splitting of the lines is possible and the data confirm this. In 16O the many measured lines are de facto the doublets what is treated as spin-orbital splitting and the average values of the doublets is taking. Namely, the first and second lines [6.049; 6.1129] take as a single [6.09]; third and fourth [6.917; 7.116] as [7.02]; seventh and eight [9.582; 9.844] as [9.71].

In this case the assumed connection between calculated and observable lower lines is

$$4(1,2-2,0) + 2(0,3-2,1) = 5.914;\ [6.09]$$

$$4(1,2-2,0) + 2(1,1-2,0) = 6.06;\ [6.09]$$

$$6(1,2-0,4) = 6.86\ [7.02]$$

$$2(1,1-2,1) + 2(1,2-1,3) = 8.85\ [8.871]$$

$$6(1,2-1,3) = 9.50\ [9.71]$$

Because (2,0) state cannot contains more of two identical fermions the fit of first excitation hints on the cluster structure of 16O or there at least one pair has boson-type nature that generates the questions. The reason of unobservable splitting for fifth line is obscured. The ambiguities, they are produced by lot of possible transitions, descend to lowest lines and the consideration of mirror nuclei is interrupted.

6.2.2 Discussion

These results offer additional argument for rejecting of the pure self-interaction in any field. In whole, that without binding with other fields the pure self-interaction of a field is source of infinite value for field energy and that the interaction with other field cut off the infinities is quite noticeable.

Taking into account the simplicity of the model, and not without exaggeration, the results on mirror nuclei structure are well.

The part of emerging questions is: the types of pionic potentials; the dependence of pionic as well as gluonic potentials on the mass number; the action of mass forces; the extensions in area of not mirror nuclei; the description of electrostatic as well as spin-orbital interactions; the possible correlations between structures of nucleus and atom; the fit of data, including NN scattering, with various models of nuclear forces; etc.

The main question is the emptiness of lowest states. It looks as consequence of Coulomb-like spectra and perhaps can be removed by mass forces. However, it is possible that nuclei hang in energetic space. In my opinion as theoretical as experimental efforts need to clear up the situation.

6.3 Lightest not mirror nuclei structure

In not mirror nucleus, because the numbers of protons, p, and neutrons, n, are not equal between themselves, the pionic field has two strong charges. Semiclassical physics has no deal with similar objects, for description of not mirror nuclei the phenomenological, even Ptolemy-like, road is opening always.

Obviously, at first step the separation of the pionic and gluonic fields contributions to nuclei energies is desirable. The transition energies are independent on gluonic field subtractions so the nuclei spectrum is considering firstly. Comparing the observable value of binding energy and the calculated binding energy in pionic field for some assumed configuration of ground state the gluonic field subtraction per nucleon is calculated that restrict the area of excitation states, then turn around if the configuration of ground state was found contradictable.

The parameters of pionic field are modified as following. Because the depth of pionic well, G, is near expected value equal to double mass of free pion the one take as for mirror nuclei

$$G = 302.316 MeV$$

Pionic field dimensionless charge takes with simplest modifications as

$$Ga = k\frac{(A-1)}{2\sqrt{pn}}(A-1)^{2/3}S^{2/3}$$

$$k = 0.3908$$

$$S = 1 - k_1\frac{|n-p|}{\sqrt{p}}$$

where in the denominator the replacement $A \to 2\sqrt{pn}$ made because any nucleus contains at least one proton together with one neutron. The $|n-p|$ term is simplest for counting of the effects caused by proton-neutron difference, but we consider only the nuclei with extra neutrons. The constant k_1 is fitting parameter. In case $S < 0$ the isotope chains are interrupted and the denominator $\sqrt{p}$ is introduced for suitable restriction of the chains length.

Having calculated numbers for the nucleon energies in pionic field together with the spectra data the nucleus structure is recognizable.

Some additional remarks want to do.

Between structure of a nucleus and his isotopes the various correlations exist. If a nucleus has no as the excited states as a gap in ground state then the jointing of additional nucleon to this nucleus is impossible. If a nucleus has no the excitations but has a gap on a shell in ground state then additional nucleon may put on free space in ground state. For example, from data the deuteron has no excitations but it has half empty ground (N=0,l=0) shell, adding the neutron on this shell we get the triton. From data the triton has no excitation and its (0,0) shell is filled by neutrons so the next, Z=1 A=4, isotope is unrelated with the triton and has another structure. If in a nucleus the ground state filled up but the excited states exist then jointing of additional nucleon is possible to first, not forbidden for excitations, shell. The alpha particle is the example of such nucleus.

Another remark concerns to inertial forces acting on off-balanced in mass nucleons. Because the mass of a nucleon relative to mass of a light nucleus is not such small as it is for electron in atom, and because the vector part of w-field potential is $\sim R^{-2}$ and in general case the potential of w-field contain a scalar part, the inertial forces give a contribution to energies even if the velocity of a nucleon, v/c, is small. These forces are more essential for odd number of additional neutrons and for excitations of a nucleus. When the mass asymmetry and may be when the distance between unpairing nucleons and the center of field, the one does not coincide always with the mass center, are increasing these forces rise up. Because the abundance of excited states is typical for any shell model we qualitatively take the inertial forces into account to restrict the lot of excited states. Also, we assume that in not mirror nuclei typically only one shell, it is the first upper relative to ground state shell, is opening for excitation and that the more symmetrical distribution of masses in ground state is optimal. Even so the extra transitions stay on, they simply are neglected.

Because gluonic field act directly on the quarks and has no deal with nucleons we take for any nucleon in the nucleus the equal subtractions.

At once, in this shell model for fixed $N + l$ the less orbital momentum

means the fewer binding energy of a nucleon in pionic field. Then typical hierarchy of a nucleon levels in pionic field is: (0,0); (0,1), (1,0); (0,2), (1,1), (2,0); (0,3), (1,2), (2,1), (3,0); etc.

Taking the triton as caliber for unknown constant calculation [below in square bracket are data, 1MeV is unit of energy, the proton for Z=1 isotopes does not differ from neutron at energies calculations, the denomination of a nucleon energy in pionic field is (p,n,N,l)] we get

$$3(1,2,0,0) - 3(1,2,0,1) = 8.48[8.481]$$

$$k_1 = 0.2125$$

Correspondingly, the isotope chains lengths are:

$$H = 6[6], He = 10[10], Li = 14[12], Be = 17[14], B = 20[19],$$

$$C = 23[22], N = 26[24], O = 29[26], etc.$$

The lengths of isotope chains are in not bad agreement with data so this parameterization of pionic potential is admissible.

For interested in subject reader is preferable instead of reading the following text to make the calculations about notmirror nuclei structure independently, and then compare the results. Using data are from NNDC tables.

$Z = 1$ chain

This chain contains four isotopes. The triton was taken for calibration of pionic field charge. Note, we regard a resonance as a state with negative binding energy of all nucleons. So the resonances of the triton cannot appear because at transition via (0,1) state the nucleons became the free particles and the nucleus break up. Because the quantity of the proton and neutron numbers is clear we simplify the denomination of the nucleon energies, labeling (N,l)=X instead of e(p,n,N,l)=X.

In $4H$ nucleus the calculated energies of nucleons in pionic field are

$$(0,0) = 6.040;\ (0,1) = 2.379;\ (1,0) = 1.990;\ (0,2) = 1.149$$

$$(1,1) = 1.108;\ (2,0) = 0.979;\ (0,3) = 0.664;$$

As was mentioned the structure of 4H and 3H differ. Natural conjecture is that it is similar to 4He structure then, because a state with zero orbital momentum cannot capture three neutrons, we assume that all nucleons of 4H are in (0,1) state. In this case the binding energy in pionic field is 9.516. Measured binding energy is [5.58], the needing subtraction per nucleon is

0.984, this is bigger of (2,0) state energy. Correspondingly, the (2,0) and all upper states are subject for resonance transitions. Because the energies of (0,2) and (1,1) states are almost equal we take the average value of the ones as $\bar{2} = 1.128$. On condition that the proton is spectator and only odd number of the neutrons can be transmitted (we do this assumption to restrict the variety of possible transitions) the excitations are:

$$1(0,1) - 1(1,0) = 0.389[0.31]$$

$$3(0,1) - 2(1,0) - 1(\bar{2}) = 2.029[2.08]$$

$$3(0,1) - 1(1,0) - 2(\bar{2}) = 2.891[2.83]$$

$$3(0,1) - 3(\bar{2}) = 3.753[?]$$

Experimental searching of last excitation is desirable.

For $5H$ isotope the calculated nucleon energies in pionic field are

$$(0,0) = 6.241;\ (0,1) = 2.497;\ (1,0) = 2.077$$

$$(0,2) = 1.211;\ (1,1) = 1.166;\ (2,0) = 1.026$$

We guess that in 5He four nucleons are together and one aside; for this reason the ground state of 5H take with four nucleons in (0,1) state and one nucleon in (1,0) state. In this case the binding energy in pionic field is 12.065 while measured is [2.7]. So needing subtraction per nucleon is 1.87 and only internal excitations from (0,1) to (1,0) state are possible. No one excitation of this nucleus was observed. For reasons given the structure of 5H take as: (0,0) state is empty; in (0,1) state are two neutrons; on (1,0) shell are two neutrons and proton. In this case, because of 1.7 subtraction, the excitations are not possible, the resonances can be found in experiment. Lowest observable resonances (see[22] and references therein, it is accessible for me article) have energies [2.7 - 2.8], these values can be realized by transitions of three nucleons from (1,0) state. For example,

$$3(1,0) - 3(0,2) = 2.6;\ 3(1,0) - 3(1,1) = 2.73;\ 3(1,0) - 3(2,0) = 3.15$$

First 'true' resonance (in our schema 'true' because we regard a resonance as excitation of all nucleons in area negative binding energies, the unbound state is more suitable denomination of not-true resonances) is

$$2(0,1) + 3(1,0) - 5(0,2) = 5.2$$

but it was not found, at least on today.

For $6H$ nucleus the data are scarce, only the value of binding energy, [5.8], is in NNDC table. For 6He the data say it is the halo nucleus, for this reason we regard the 6H as halo nucleus also. This means that two neutrons of 6H are moving in pionic field of core which is the 4H nucleus and so all nucleons are moving in p=1, n=3 pionic field. If the halo neutrons are in (1,0) state the binding energy of 6H in pionic field is 13.496 and needing subtraction per nucleon, 1.37, close all states of p=1, n=3 pionic field for excitations. One internal excitation of the proton from (0,1) to (1,0) state with 0.389 energy is possible if dividing of the one from 4H core is possible without breaking the nucleus. In own (p=1, n=5) pionic field the lot of excitations arise for any compatible with the value of binding energy configuration of ground state. Searching the excitations will clear up the structure of 6H nucleus.

$Z = 2$ chain

For simplicity the electrostatic energies will be ignored so the proton and neutron energies are identical. Because the ground state of 4He is without vacancies the extra neutrons are jointing to upper states.

In $5He$ nucleus the lower states of the neutron in p=2, n=3 pionic field are

$$(0,0) = 9.055;\ (0,1) = 4.516;\ (1,0) = 3.478;\ (0,2) = 2.359$$

If configuration of ground state is 2p(0,0)+2n(0,0)+1n(0,1) then, because mesuared binding energy of this nucleus is [27.41], the needing subtraction, 2.66, leaves the state (1,0) free for excitations. The first of the possible transitions is

$$1(0,1) - 1(1,0) = 1.038$$

the next corresponds to the excitations of alpha particle with energy near 20. In work [23] such structure was observable, for this reason the selected structure of 5He has advantage. However, because of maximal binding energy in pionic field, we expect the stability of this nucleus and observable unstable ground state stands up the question. Additionally, the 5He and 5H structures are not similar so or in the 5H are excitations or the puzzle arise in this model.

For $6He$ isotope, after looking on the nucleon energies in p=2, n=4 pionic field became clear they did not lead to satisfactory adjusting of the excitation energies. Because the experiments inclined the ones regard this isotope as halo nucleus we supposed that two extra nucleon of 6He as well as the nucleons of virtual alpha particle core are moving in pionic p=2, n=2 field. The energies of the neutron in this field are

$$(0,0) = 7.721;\ (0,1) = 3.471;\ (1,0) = 2.768$$

$$(0,2) = 1.744;\ (1,1) = 1.653;\ (2,0) = 1.410$$

With alpha particle on (0,0) shell and two neutrons in (0,1) state the nucleus energy in pionic field is 37.827, observable binding energy is [29.269]. Needing subtraction per nucleon, 1.43, is somewhat bigger of (2,0) state energy and so this and upper states are subjects for resonance transitions. The gap between (0,2) and (1,1) states is small, for this reason we take the averaging energy of the last excited levels as $(\bar{2}) = (0, 2+1, 1)/2 = 1.698$. The agreements with data have following transitions

$$1(0,1) - 1(\overline{2}) = 1.773\ [1.797]$$

$$1(0,0) + 1(0,1) - 2(1,0) = 5.656\ [5.6]$$

$$2(0,0) + 1(0,1) - 3(\overline{2}) = 13.819\ [13.9]$$

$$2(0,0) + 2(0,1) - 4(\overline{2}) = 15.592\ [15.5]$$

$$4(0,0) - 4(\overline{2}) = 24.052\ [24.2]$$

Extra, not observable excitations were discarded. For today theory it is not bad result. However, the core has strange softness because one nucleon transitions from core are presented while for real alpha particle the (0,0) to (0,1) transitions are in facto suppressed.

Lower $7He$ neutron states in p=2, n=5 pionic field are

$$(0,0) = 10.094;\ (0,1) = 5.455;\ (1,0) = 4.099;\ (0,2) = 2.952$$

Observable binding energy of this nucleus is [28.82] and two excitations with [2.92; 5.83] energies were found in the experiments. These numbers say that only the (1,0) state is opened for excitations and here are few possibilities of the nucleons distribution on (0,0) and (0,1) shells. We take the cluster structure of this nucleus. Namely, single proton with two neutrons are in (0,0) state that corresponds to virtual triton, one proton with three neutrons are in (0,1) state as virtual 4H nucleus. Needing subtraction, 3.4, leaves only the (1.0) state free for excitations. The cluster model has some advantage because we can require that the nucleon transitions between clusters or break up the nucleus or lead to new cluster mode. In this way, because of Z=1 nuclei structure, the excitations from (0,0) to (0,1) state are forbidden. Also we assume that from virtual triton the odd number while from virtual 4H the

even number of nucleons can be excited. With these restrictions the possible three excitations are

$$2(0,1) - 2(1,0) = 2.712; \text{ [2.92]}$$

$$1(0,0) - 1(1,0) = 6.0; \text{ [5.83]}$$

$$3(0,0) - 3(1,0) = 18.0; \text{ [?]}$$

This cluster model of 7He nucleus can be tested by searching the third excitation.

In $8He$ nucleus the neutron energies in pionic field are

$$(0,0) = 9.714;\ (0,1) = 5.098;\ (1,0) = 3.864;\ (0,2) = 2.721$$

and from experience with previous He isotopes we expect that states above of (1,0) belong to resonance transitions area. Taking into account that (1,0) state can take on board no more of two neutrons with two protons the lowest excitation energies are

$$1(0,1) - 1(1,0) = 1.234\ [absent]$$

$$2(0,1) - 2(1,0) = 2.468$$

$$3(0,1) - 3(1,0) = 3.702$$

$$(2.468 + 3.702)/2 = 3.08 [3.1]$$

so the puzzle is with first excitation. Because $4(0,1) - 4(1,0) = 4.936$ transition is not presented in data we assume that (1,0) state contains one nucleon. With configuration 3(0,0)+4(0,1)+1(1,0) the (1,0) state is the last open for excitations as we assumed initially. Next transitions contain the single nucleons of (0,0) state (this is the reason for placing three nucleons in the (0,0) state), they are

$$1(0,0) - 1(0,1) = 4.616 \text{ [4.3]}$$

$$1(0,0) - 1(1,0) = 5.850 \text{ [6.03]}$$

For last observable on today excitation are few variants with almost equal energies, one of them is

$$1(0,0) + 1(0,1) - 2(1,0) = 7.084 \text{ [7.16]}$$

Additional roads exist here. For example, if the possible excitation of two or three nucleons to (0,1) or (1,0) states will be not observable then (0,0) state is occupied by one nucleon only and the questions stand up.

In $9He$ nucleus the neutron energies in pionic field are

$$(0,0) = 8.358;\ (0,1) = 3.947;\ (1,0) = 3.095;\ (0,2) = 2.099$$

$$(1,1) = 1.900\ (2,0) = 1.600$$

Proper configuration of 9He ground state is: the proton with two neutrons in (0,0) state; one proton and three neutrons in (0,1) state; two neutrons in (1,0) state. In this case the binding energy of the nucleus in pionic field is 47.052 while observable binding energy is [30.26]. So needing subtraction per nucleon, 1.86, shut down the (2,0) and upper states for excitations, however (1,1) state can be forbidden also. For avoid this uncertainty we take the middle energy of (0,2) and (1,1) states, namely $(\bar{2}) = 2.0$. Two lowest excitations are

$$1(1,0) - 1(\bar{2}) = 1.095;\ [1.1]$$

$$2(1,0) - 2(\bar{2}) = 2.19\ [2.26]$$

In the next excitations the neutrons of (0,1) state are involved. Because (1,0) state is filled by neutrons we assume that neutrons transitions from (0,1) state lifted both neutrons of (1,0) shall. In this case

$$2(1,0) - 2(\bar{2}) + 1(0,1) - 1(\bar{2}) = 4.237\ [4.2]$$

$$2(1,0) - 2(\bar{2}) + 2(0,1) - 1(1,0) - 1(\bar{2}) = 4.989\ [5.0]$$

$$2(1,0) - 2(\bar{2}) + 3(0,1) - 3(\bar{2}) = 8.031\ [8.0]$$

$$2(1,0) - 2(\bar{2}) + 4(0,1) - 4(\bar{2}) = 10\ [?]$$

Last measured excitation has [8.0] energy so the nucleons of (0,0) state can be the spectators of the excitations. Also it is unclear why the proton from (0,1) shell does not fall to (0,0) state. Maybe such transition breaks up the nucleus but, because of electrostatic interaction between protons, it looks as electromagnetic process.

In $10He$ the energies of the neutrons in pionic field are

$$(0,0) = 4.809;\ (0,1) = 1.721;\ (1,0) = 1.493;$$

Maximal binding energy is reached when on (0,0) shell four and on (0,1) shell six nucleon are placed. In this case the pionic part of binding energy is 29.56 while measured binding energy is [30.34]. This absurd result requires the best tuning in the model if the 10He is particle.

$Z = 3$ chain

In *7Li nucleus* the neutron levels are

$$(0,0) = 11.847;\ (0,1) = 7.305;\ (1,0) = 5.304;$$

$$(0,2) = 4.243;\ (1,1) = 3.711;\ (2,0) = 2.916;$$

First observable excitation is small and far from next transition, of course for 7Li scales; only one transition, (0,2) to (1,1), has accordance with these. On this ground the structure of 7Li take as: three nucleons in (0,0), three in (0,1) and one in (0,2); the (1,0) shell is empty. For such configuration the binding energy in pionic field is 61.699 while observable is [39.244] and so the subtraction 3.21 reserve the (1,1) state for excitations. We restrict the number of possible transitions as: (1,0) state is closed for any transition; only odd number of nucleons can be transferred. Then suitable transitions are:

$$1(0,2) - 1(1,1) = 0.452\ [0.4776];$$

$$1(0,0) - 1(0,1) = 4.542\ [4.630]$$

$$2(0,1) - 2(0,2) + 1(0,2) - 1(1,1) = 6.576\ [6.680]$$

$$2(0,1) + 1(0,2) - 3(1,1) = 7.480\ [7.459]$$

$$3(0,1) - 2(0,2) - 1(1,1) = 9.638\ [9.67]$$

$$3(0,1) - 1(0,2) - 2(1,1) = 10.090\ [9.850]$$

$$1(0,1) - 1(0,2) + 1(0,1) - 1(1,1) + 1(0,0) - 1(0,1) = 11.118\ [11.240]$$

$$1(0,0) + 2(0,1) - 3(0,2) = 13.728\ [13.7]$$

$$1(0,0) - 1(0,2) + 2(0,1) - 2(1,1) = 14.632\ [14.7]$$

Here are possible but not observable excitations, they were skipped. The result for 7Li spectrum is acceptable , however it is achieved due to strange structure of this nucleus.

In *8Li nucleus* the energies of the neutron levels in pionic field are:

$$(0,0) = 12.195;\ (0,1) = 7.711;\ (1,0) = 5.569$$

$$(0,2) = 4.551;\ (1,1) = 4.042$$

The value of the first observable excitation gives little doubts for placing in (1,0) state at least the one nucleon, because of 8He structure we take single nucleon in this state. However, the 8He and 8Li structures are nonidentical. We take for 8Li the structure of ground state as: four nucleons in (0,0), three in (0,1) and one in (1,0) state. Then, because of 41.277 value for observable binding energy, the needing subtraction is 4.526 per nucleon and the (0,2) state is the excitation level while the (1,1) state belongs to resonance levels. For this ground state the excitations, containing only odd number of nucleons and without involving the nucleons from (0,0) state, are

$$1(1,0) - 1(0,2) = 1.018\ [0.98]$$

$$1(0,1) - 1(1,0) = 2.142\ [2.255]$$

$$1(1,0) - 1(0,2) = 3.160\ [3.21]$$

$$1(1,0) - 1(0,2) + 2(0,1) - 2(1,0) = 5.302\ [5.4]$$

$$1(0,1) - 1(1,0) + 1(0,1) - 1(0,2) + 1(1,0) - 1(0,2) = 6.320[6.1]$$

$$3(0,1) - 3(1,0) = 6.426[6.53]$$

$$2(0,1) - 2(0,2) + 1(1,0) - 1(0,2) = 7.338[7.1]$$

$$2(0,1) - 2(0,2) + 1(0,1) - 1(1,0) = 8.462[9.0]$$

$$3(0,1) - 3(0,2) = 10.07[9.67]$$

Because the transitions from (0,0) state are not presented we can expect the existence of the alpha particle excitations with energy near 20 Mev.

Likewise, for $9Li$ nucleus the neutron energies in p=3, n=5 pionic field are:

$$(0,0) = 12.295;\ (0,1) = 7.832;\ (1,0) = 5.648;$$

$$(0,2) = 4.551;\ (1,1) = 4.117;\ (2,0) = 3.232$$

With restriction that even number of nucleons can be send from state to state the suitable excitations are:

$$1(0,2) - 1(1,1) + 1(0,1) - 1(1,0) = 2.711[2.695]$$

$$2(0,1) - 2(1,0) = 4.368[4.3]$$

$$2(0,1) - 1(1,0) - 1(0,2) = 5.372[5.38]$$

$$2(0,1) - 2(0,2) = 6.376[6.43]$$

$$2(0,1) + 2(0,0) - 4(0,2) = 17.678[17.1]$$

$$2(0,1) - 2(1,1) + 2(0,0) - 2(0,2) = 18.732[18.9]$$

This result is acceptable.

For next Z=3 isotopes the database still is not completed and we interrupt the calculations for this chain.

$Z = 4\ chain$

In $9Be$ the levels in pionic field are:

$$(0,0) = 13.625;\ (0,1) = 9.521;\ (1,0) = 6.768;$$

$$(0,2) = 6.037;\ (1,1) = 5.225;\ (2,0) = 4.036$$

Let us take the ground state configuration as: four nucleons in (0,0), three in (0,1) and two in (1,0) state. Observable binding energy, 58.164, requires the subtraction 4.38 per nucleon what leaves the (0,2) and (1,1) states free for excitations. The lower of the ones are

$$(1,0) - (0,1) = 1.543;\ [1.684]$$

$$2(1,0) - (0,2) - (1,1) = 2.274;\ [2.429]$$

$$(0,1) - (1,0) = 2.753; \text{ [2.78]}$$

$$2(1,0) - 2(1,1) = 3.086; \text{ [3.049]}$$

For next excitation few variants available and we skip all the ones.

$10Be$ energy levels of the neutrons in pionic are:

$$(0,0) = 13.774;\ (0,1) = 9.722;\ (1,0) = 6.904;\ (0,2) = 6.214;$$

$$(1,1) = 5.364;\ (2,0) = 4.137;$$

It seems the configuration of ground state with three nucleons in (0,0) and seven in (0,1) state has preference. In this case the small excitations are absent and the single nucleon transitions from (0,0) state are allowed. Needing subtraction per nucleon leaves as excitation levels the (0,2) and (1,1) states. Compatible with data the lower transitions are

$$(0,1) - (0,2) = 3.508; \text{ [3.368]}$$

$$2(0,1) - 2(1,0) = 5.636; \text{ [5.958; 5.959]}$$

$$2(0,1) - 1(1,0) - 1(0,2) = 6.326; \text{ [6.179; 6.263]}$$

$$2(0,1) - 1(0,2) - 1(1,1) = 7.176; \text{ [7.371]}$$

$$(0,0) - (0,2) = 7.560; \text{ [7.542]}$$

$11Be$ levels of the neutron in pionic field are

$$(0,0) = 13.788;\ (0,1) = 9.741;\ (1,0) = 6.916;$$

$$(0,2) = 6.230;\ (1,1) = 5.376;\ (2,0) = 4.147$$

The first observable excitation of this nucleus, [0.320], is so small that in whole beryllium chain is impossible to find the one. So we take the ground state of this nuclide with four nucleons in (0,0), seven in (0,1) and one in (1,0) state. In this case the needing subtraction is 5.0 that leaves the (0,2) and (1,1) states free for excitations. Suitable transitions are

$$(1,0) - (0,2) = 0.686; \text{ [0.320]}$$

$$(1,0)-(1,1)=1.540;\ [1.778]$$

$$(0,1)-(1,0)=2.825;\ [2.690]$$

$$(0,1)-(0,2)=3.511;\ [3.410]$$

$$(0,0)-(0,1)=4.047;\ [3.887;\ 3.956]$$

$$(1,0)-(1,1)+(0,1)-(0,2)=5.051;\ [5.290]$$

$$(1,0)-(1,1)+(0,1)-(1,1)=5.905;\ [5.860]$$

$$2(0,1)-(1,0)-(0,2)=6.336;\ [6.510]$$

$$(0,0)-(1,0)=6.872;\ [6.705]$$

$$2(0,1)-2(0,2)=7.022;\ [7.030]$$

$$2(0,1)-2(1,1)=8.730;\ [8.816]$$

$$2((0,1)-2(1,1)+(1,0)-(1,1)=10.270;\ [10.590]$$

$$2(0,0)-2(1,1)+(1,0)-(1,1)=18.304;\ [18.50]$$

As for previous nuclei the extra theoretical excitations were skipped.

Of $12Be$ neutron levels in pionic field are

$$(0,0)=13.637;\ (0,1)=9.538;\ (1,0)=6.779$$

$$(0,2)=6.051;\ (1,1)=5.236;\ (2,0)=4.045;$$

With four nucleons in (0,0), six in (0,1) and two in (1,0) state the binding energy of 12Be in pionic field is 125.334, measured is [68.65], needing subtraction per nucleon 4.7, the (0,2) and (1,1) states are free for excitations. At assumptions that from (1,0) state even numbers of nucleons, from (0,1) odd numbers of the ones can be transmitted and the particles from (0,0) state have

no part in the transitions the excitations of 12Be, which agree with measured values, are

$$2(1,0)-(0,2)-(1,1)=2.271;\ [2.102]$$

$$(0,1)-(1,0)=2.759;\ [2.702]$$

$$(0,1)-(1,1)=4.302;\ [4.560]$$

$$2(1,0)-(0,2)-(1,1)+(0,1)-(0,2)=5.758;\ [5.700]$$

Also the configuration of ground state with four nucleons in each of (0,0), (0,1) and (1,0) states is in agreement with measured on today spectrum of 12Be.

The spectra of next beryllium nuclides still absent in data tables and so, in this model, the structure of the ones is unclear.

$Z=5$ chain

Because the first observable lines determinate the structure of the nuclei we will regard the few lower transitions only. Note, beginning from boron the usual order of states is destroyed even for first levels, the energy module of (0,3) state is bigger of the one for (2,0) state. Along all this chain the difference between the energies of (1,0) and (0,2) states is near 0.3 what is smaller compare with the interval between these states and their first neighbors; these two states form the shell as it is in common approach where counting of radial quantum number keep off; the smallness of in-shell gap can be useful for determination of (1,0) state filling. For briefness the nucleon energies in pionic field are not printed.

$11B$ structure take as: four nucleons in (0,0), five in (0,1), the (1,0) is empty, two nucleons are in (0,2) state. In this case the (1,1) and (0,3) states are the upper state open for excitations. Assuming the even number of nucleons can be transmitted the lowest excitations for fitting of the two lowest measured ones are

$$2(0,2)-2(1,1)=2.346\ [2.184]$$

$$(0,2)-(1,1)+(0,1)-(1,0)=4.458\ [4.444]$$

or

$$2(0,2)-2(0,3)=4.866\ [4.444]$$

Big values of first excitations and absence of the transitions to which the 0.3 energy can be related caused the choice of 11B ground state with empty

(1,0) state. Theoretical transitions, with which we can expect fitting of third observable line, are

$$(0,2)-(1,1)+(0,1)-(1,0)=4.461$$

$$(0,2)-(0,3)+(0,1)-(1,0)=5.718,$$

did not do this, however the middle value

$$(4.461+5.718)/2=5.080\ [5.020]$$

is acceptable. Three next theoretical transitions are

$$2(0,1)-2(1,0)=6.570\ [6.742]$$

$$2(0,1)-(1,0)-(0,2)=6.888\ [6.791]$$

$$2(0,1)-2(0,2)=7.206\ [7.285]$$

Evidently, if the odd number of the nucleons will take part in transitions they destroy the result; this is the ground to allow the excitations of even number of the nucleons only.

For $12B$ nucleus the cluster structure of ground state, with four nucleons in each of (0,0), (0,1) and (1,0) shell, has some advantage. In this case the (0,2), (1,1), (0,3) and (2,0) shells belong to excitation states and suitable lower excitations are

$$4(1,0)-4(0,2)=1.188\ [0.953]$$

$$2(1,0)-(0,2)-(1,1)=1.784\ [1.637]$$

$$4(1,0)-3(0,2)-(1,1)=2.378\ [2.160]$$

$$2(1,0)-2(1,1)=2.974\ [2.723]$$

$$2(1,0)-(0,2)-(2,0)=3.316\ [3.389]$$

$$4(1,0)-3(0,2)-(0,3)=3.634\ [3.759]$$

These look as the excitations of virtual alpha particle which holds integrity at small perturbation but for bigger excitations lost the one, however the even

number of nucleons is acting. For another structure of 12B the absences of the excitations which have the energies near 0.3 will require the explanations.

$13B$ ground state take with four nucleons in (0,0), eight in (0,1) and one in (1,0) state. In this case the subtraction 5.63 leaves (0,2) and (1,1) states in the excitation field. On the nucleon in (1,0) state assume that it cannot be transmitted alone. Suitable lower excitations are

$$(0,1) - (1,0) = 3.294 \text{ [3.482]}$$

$$(0,1) - (0,2) = 3.604 \text{ [3.534; 3.681]}$$

$$(0,1) - (0,2) + (1,0) - (0,2) = 3.914 \text{ [3.712; 4.131]}$$

$$(0,1) - (1,1) = 4.783 \text{ [4.829]}$$

$$(0,1) - (0,2) + (1,0) - (1,1) = 5.093 \text{ [5.024; 5.106]}$$

Double values of measured transitions we refer to spin-orbital splitting of the levels.

$14B$ ground state with four nucleons in (0,0), seven in (0,1) and three in(1,0) state is acceptable. In this case the gluonic field shut down the states above of (1,1) state and six available in database excitations can be fitted as

$$(1,0) - (0,2) = 0.365 \text{ [}absent\text{]}$$

$$2(1,0) - 2(0,2) = 0.730 \text{ [0.790]}$$

$$(1,0) - (1,1) = 1.498 \text{ [1.380]}$$

$$2(1,0) - (0,2) - (1,1) = 1.863 \text{ [1.860]}$$

$$3(1,0) - 2(0,2) - (1,1) = 2.228 \text{ [2.080; 2.320]}$$

$$2(1,0) - 2(1,1) = 2.996 \text{ [2.970]}$$

Some of possible excitations were skipped.

For next Z=5 nuclides the database of NNDC does not contain the spectra and we consider the next string of nuclei.

In $Z = 6$ chain the (0,2), (1,0) states are almost degenerated and form a shell. We will regard these two states as single and note the one as $\bar{2}$. The same is for (1,2) and (2,0) states which denominate as $\bar{3}$.

For $13C$ take the ground state as: four nucleons in (0,0), eight in (0,1) and one in (0,3) state. In this case the free levels are: $\bar{2}$, (1,1) and $\bar{3}$. The restrictions of possible transitions are: only the excitation of odd number of the nucleons is permitted, the excitation of the nucleon from (0,3) state alone is forbidden. In this case, skipping the extra transitions, the lower excitations are

$$(0,0) - (0,1) = 3.175 \text{ [3.083]}$$

$$(0,1) - \bar{2} = 3.601 \text{ [3.684; 3.853]}$$

$$(0,0) - \bar{2} = 6.776 \text{ [6.864]}$$

$$2(0,0) - 2(0,1) + (0,3) - \bar{3} = 6.967 \text{ [6.864]}$$

$$(0,0) - (0,1) + (0,1) - \bar{2} + (0,3) - \bar{3} = 7.393 \text{ [7.492]}$$

$$2(0,1) - 2(\bar{2}) + (0,3) - \bar{3} = 7.814 \text{ [7.547; 7.686]}$$

$$(0,0) - (1,1) = 8.231 \text{ [8.20]}$$

Note, the structure and forbidden rules for 13C are similar to the ones for 13B and 7Li nuclei.

$14C$ and 13C levels in pionic field differ on 0.001MeV. However, their spectral data are not coincide and we regard the ground state of 14C with four nucleons in (0,0) and ten in (0,1) state. Then (0,3) state is the last open for excitations. Possible transitions restrict allowing only even type of the excitations. In this case theoretical excitations and their assumed correspondence with data are

$$2(0,0) - 2(0.1) = 6.350 \text{ [6.093; 6.583]}$$

$$(0,0) - (0,1) + (0,1) - \bar{2} = 6.776 \text{ [6.728; 6.902]}$$

$$2(0,1) - 2(\bar{2}) = 7.202 \text{ [7.012; 7.341]}$$

$$(0,1) - (1,1) + (0,0) - (0,1) = 8.231 \text{ [8.317]}$$

$$2(0,1) - \bar{2} - (1,1) = 8.657 \; [absent]$$

$$2(0,1) - \bar{2} - (0,3) = 9.800 \; [9.746;\; 9.801]$$

The correspondence between one calculated and two measured excitations can be caused as spin-orbital interaction as double nature of some states and pairing type of transitions.

For $15C$ the ground state take with four nucleons in (0,0), ten in (0,1) and one in (1,1) state. As a result the gluonic field lets (0,3) state as upper in the excitation set. Suitable for data fitting are the transitions

$$(1,1) - (0,3) = 1.154 \; [0.740]$$

$$(0,0) - (0,1) = 3.204 \; [3.103]$$

$$(0,0) - (0,1) + (1,1) - (0,3) = 4.358 \; [4.220]$$

$$(0,1) - \bar{2} + (1,1) - (0,3) = 4.748 \; [4.657;\; 4.78]$$

The $\bar{3} - (2,1)$ transition gives best fit of the first line. However, for opening $\bar{3}$ state the lower nucleons need move on upper states and extra transitions appear.

$16C$ database contains only six excitations and we can attempt to do more exact fit. Obviously, it can be reached distributing the nucleons between many states. This increase the number of possible transitions and gives possible to get best fit. However, the number of extra, not observable excitations will enlarge also. The neutron levels in p=6, n=10 pionic field are

$$(0,0) = 15.580;\; (0,1) = 12.310;\; \bar{2} = (0,2) = (1,0) = 8.734;\; (1,1) = 7.304;$$

$$(0,3) = 6.129;\; \bar{3} = (1,2) = (2,0) = 5.581;\; (2,1) = 4.832;\; (0,4) = 4.409$$

Let as take the ground state configuration as: four nucleons in (0,0), six in (0,1), four in $\bar{2}$, one in (1,1) and one in (0,3) state. The value of measured binding energy, 110.753, is reached with subtraction 4.76 and so the (2,1) is upper real state of 16C. Suitable schema, involving the even number nucleon transitions only, is

$$(0,3) - \bar{3} + (1,1) - (0,3) = 1.723 \; [1.766]$$

$$(0,3)-(2,1)+(1,1)-\bar{3}=3.020\ [3.027]$$

$$(0,0)-(0,1)+(0,3)-\bar{3}=3.818\ [3.986]$$

$$(0,1)-\bar{2}+(0,3)-\bar{3}=4.124\ [4.088;\ 4.142]$$

$$(0,1)-(1,1)+(1,1)-(0,3)=6.181\ [6.109]$$

The excitations of two upper nucleons look as if they are jointed and did not loss the hierarchy in the transitions. For excitations of lower nucleons the driving order to cut off the extra excitations is not noticeable easily.

In $17C$ the usual order of (1,0) and (0,2) states is restored, namely

$$(1,0)=8.487;\ (0,2)=8.384$$

With four nucleons in (0,0), ten in (0,1) and three in (1,0) state the transition

$$3(1,0)-3(0,2)=0.309\ [0.295]$$

fits existing on today the one measured excitation of 17C.

For $18C$ the data tables offer one excitation. With natural assumption that even number of nucleons is involved in interaction the explanation of observable number can be following. The transition of one nucleon from (1,1) to (0,3) state is supplemented by small in-shell (1,0)-(0,2) excitation, namely

$$(1,1)-(0,3)+(1,0)-(0,2)=1.502;\ [1.620]$$

Then maximal packing of the nucleons in pionic field is: four in (0,0), ten in (0,1), three in (1,0) and one in (1,1) state. In this case needing subtraction, 5.002, leaves the (2,0) state in real area and the next predicted transition is

$$(1,1)-(2,0)+(1,0)-(0,2)=1.785;\ [?]$$

So the plausible expectation is that observable [1.620] transition has double structure. Perhaps it can be checked with available data.

$Z=7$ chain.

$15N$ structure take as: for nucleons in (0,0), six in (0,1), zero in (0,2) and four in (1,0) state. The subtraction 5.68 leaves (2,1) to be the last real state. On the lower excitations of this nuclide the following is assumed. Even number of nucleons is involving in transferring. The nucleons of (0,0) state are excited together and so they are not lower transitions. The (0,2) state keeps empty. The nucleons of (1,0) state are or excited at once or the nucleon

of (0,1) state knock out a nucleon from (1,0) state and then stopped in (1,0) state or is going upper. Because the schema is complicated we regard more transitions. The lower excitations of 15N are

$$(0,1)-(1,0)+(1,0)-(1,1)=5.208\ [absent,\ or\ 5.270]$$

$$4(1,0)-4(1,1)=5.284\ [5.270;\ 5.298]$$

$$(0,1)-(1,0)+(1,0)-(1,3)=6.183\ [6.323]$$

$$(0,1)-(1,1)+(1,0)-(1,1)=6.529\ [6.323]$$

$$(0,1)-(1,0)+(1,0)-(1,2)=6.946\ [7.155]$$

$$(0,1)-(1,0)+(1,0)-(2,0)=7.194\ [7.155]$$

$$(0,1)-(1,1)+(1,0)-(0,3)=7.502\ [7.300]$$

$$(0,1)-(1,0)+(1,0)-(2,1)=7.919\ [7.567]$$

$$(0,1)-(1,1)+(1,0)-(1,2)=8.267\ [8.312]$$

$$(0,1)-(1,1)+(1,0)-(2,0)=8.515\ [8.571]$$

$$?\ [9.049]$$

$$4(1,0)-4(0,3)=9.176\ [9.151;\ 9.154]$$

$$(0,1)-(1,1)+(1,0)-(2,1)=9.240\ [9.222]$$

The [9.049] excitation falls out of the schema. The (0,2) state was taken empty because the transitions containing (0,2)-(1,0)=0.464 were not observed. Note, the electrostatic interaction begins to bring the detectable corrections of the spectra, they are ignored.

$16N$ structure cannot be simple because the lowest measured excitations are small. We take the ground state of this nucleus as

$$4(0,0)+5(0,1)+1(0,2)+3(1,0)+3(2,2)$$

In this case the subtraction, 4.343, leaves (3,0) state, which is above of (2,2), as last real state. We suppose that (1,0) state contains virtual triton and (0,0) state virtual alpha particle, which, at least for small energies, are excited as whole. Assumed connections between calculated and measured excitations are

$$(2,2)-(3,0)=0.143\ [0.120]$$

$$2(2,2)-2(3,0)=0.286\ [0.298]$$

$$3(2,2)-3(3,0)=0.429\ [0.397]$$

$$(0,2)-(1,0)=0.449\ [0.397]$$

$$(0,1)-(0,2)=3.430\ [3.353]$$

$$(0,2)-(1,1)=1.773\ [absent]$$

$$(0,2)-(0,3)=2.754\ [absent]$$

$$(0,2)-(1,2)=3.511\ [3.523]$$

$$(0,2)-(2,0)=3.751\ [?]$$

$$(0,1)-(1,0)=3.879\ [3.963]$$

$$3(1,0)-3(1,1)=3.972\ [3.963]$$

$$(0,1)-(1,0)+3(2,2)-3(3,0)=4.308(\ [4.320]$$

$$(0,2)-(2,1)=4.481\ [4.391]$$

$$(0,2)-(0,4)=4.700\ [4.760;\ 4.783]$$

$$(0,2)-(1,3)=5.034\ [5.054]$$

The [4.320] excitation is realized somewhat artificially and the extra transitions are presented but in whole the result is acceptable.

$17N$ ground state take as

$$4(0,0)+11(0,1)+1(0,2)+1(1,0)$$

Needing subtraction, 6.47, holds the (1,2) state in real domain. Assuming that (0,0) nucleons are transmitted by pairs the lower one nucleon transitions can be connected with observable numbers as

$$(0,2)-(1,0)=0.410\ [absent]$$

$$(1,0)-(1,1)=1.334\ [1.373]$$

$$(0,2)-(1,1)=1.744\ [1.849;\ 1.906]$$

$$(1,0)-(0,3)=2.335\ [2.526]$$

$$(0,2)-(0,3)=2.745\ [2.526]$$

$$(1,0)-(0,2)=3.073\ [3.128;\ 3.204]$$

$$(0,1)-(0,2)=3.447\ [3.628;\ 3.663]$$

$$(0,1)-(1,0)=3.857\ [3.628;\ 3.663]$$

The (0,2)-(1,2)=3.483 transition can be suppressed, it was omitted. Note, the middle value (3.447+3.857)/2=3.652 gives best fit of [3.628; 3.663] excitations.

$18N$ ground state take as

$$4(0,0)+3(0,1)+7(0,2)+2(1,0)+2(2,2)$$

needing subtraction is 4.181; because (3,0)=4.404 while (0,5)=3.935 the (3,0) is the last state of excitation set. The transitions restrict permitting the excitations from (0,2) and (2,2) states only with odd number of nucleons involved in. Possible connection between calculated and measured excitations is

$$(2,2)-(3,0)=0.107;\ [0.144];$$

$$(0,2)-(1,0)+2(2,2)-2(3,0)=0.556;\ [0.587];$$

$$2(0,2)-2(1,0)+(2,2)-(3,0)=0.793\ [0.747]$$

$$(0,2)-(1,1)=1.693\ [1.734]$$

$$2(0,2)-(1,0)-(1,1)+(2,2)-(3,0)=2.142\ [2.210]$$

$$3(0,2)-2(1,0)-(1,1)=2.377\ [2.420]$$

$$3(0,2)-2(1,0)-(1,1)+2(2,2)-2(3,0)=2.594\ [2.614]$$

On today these are all excitations offered by database.

$19N$ measured excitations are bigger of (0,2)-(1,0) energy and we take the mixture of these states as $\bar{2}=(9.519+9.280)/2=9.4$. Chosen configuration of ground state is

$$4(0,0)+12(0,1)+2(\bar{2})+1(1,1)$$

Odd number of nucleons can be transmitted only; it is expected restriction for the isotope with odd mass number. In this case the excitations are

$$(1,1)-(0,3)=1.082;\ [1.11]$$

$$\bar{2}-(1,1)=1.496;\ [1.65]$$

$$(1,1)-(1,2)=1.738;\ [1.65]$$

$$\bar{2}-(0,3)=2.578;\ [2.54]$$

$$\bar{2}-(1,2)=3.234;\ [3.47]$$

$$2(\bar{2})-2(1,1)+(1,1)-(0,3)=4.074;\ [4.18]$$

These are available on today measured excitations of 19N. Perhaps not single nature of [1,65] transition can be checked with existing data.

For next Z=7 nuclides the excitation spectra are absent, at least in NNDC tables.

$Z=8$ chain

For $17O$ ground state the selected configuration is

$$4(0,0)+11(0,1)+2(1,2)$$

In this case the last excitation state is (2,0) and the transition

$$2(1,2)-2(2,0)=0.872\ [0.870]$$

gives good fit. So we assume that in lower excitations the even number of nucleons take part. Next excitations are

$$(0,0)-(0,1)+(1,2)-(2,0)=2.927\ [3.055]$$

$$(0,1)-(0,2)+(1,2)-(2,0)=3.690\ [3.842]$$

$$((0,1)-(1,0)+(1,2)-(2,0)=4.481\ [4.558]$$

$$2(0,0)-2(0,1)=4.982\ [5.084]$$

$$(0,1)-(1,1)+(1,2)-(2,0)=5.714\ [5.697]$$

$$(0,1)-(0,2)+(0,0)-(0,1)=5.745\ [5.732]$$

$$2(0,0)-2(0,1)+2(1,2)-2(2,0)=5.854\ [5.869]$$

There were skipped [5.215; 5.379] observable excitations; they can be considered as

$$(0,1)-(1,1)=5.278\ [5.215;\ 5.379]$$

It can be treated as special properties of not gamma transitions.

In $18O$ the energy interval between measured neighbouring excitations is small almost from second transition; that cannot be grasped by simple model reliably. Nevertheless, we continue the consideration of the isotope structure. Ground state of 18O takes as

$$4(0,0)+0(0,1)+12(0,2)+1(1,0)+1(1,1)$$

The empty (0,1) state produced small value of needing subtraction, 4.6, what lets many roads for excitations. The lower transitions restrict by even number of nucleons. Because the energy gap between (2,1) and (0,4) states is 6.300-6.327=0.023 we denominate these states as single $\bar{2}$. The transition from (1,0) to (0,3) is suppressed by big orbital momentum difference so this transition is discarded. First excitation series is

$$(1,0)-(1,1)+(1,1)-(0,3)=2.035\ [1.982]$$

$$(1,0)-(1,1)+(1,1)-(1,2)=2.956\ [absent]$$

$$(1,0)-(1,1)+(1,1)-2,0)=3.377\ [3.554]$$

$$(1,0)-(1,1)+(1,1)-\bar{2}=4.095\ [3.920]$$

$$(1,0)-(1,1)+(1,1)-1,3)=4.540\ [4.455]$$

$$(1,0)-(1,1)+(1,1)-(2,2)=5.089\ [5.097]$$

$$(1,0)-(1,1)+(1,1)-(3,0)=5.349\ [5.336;\ 5.377]$$

Next series are

$$(1,0)-(1,2)+(1,1)-(0,3)=3.754\ [3.633]$$

$$(1,0)-(1,2)+(1,1)-(1,2)=4.672\ [4.455]$$

$$(1,0)-(1,2)+(1,1)-(2,0)=5.193\ [5.097]$$

$$(1,0)-(2,0)+(1,1)-(0,3)=4.172\ [3.920]$$

$$(1,0)-(2,0)+(1,1)-(1,2)=5.093\ [5.097]$$

$$(1,0)-(2,0)+(1,1)-\bar{2}=5.514\ [5.530]$$

On the transitions from (0,2) state we assume that the lower ones contain four nucleons. Because in (1,0) state is the nucleon it is involved in the transition (0,2)-(1,0) also; then, because of supposed even structure of the excitations, the nucleon of (1,1) state is involved too. So the first excitation of (0,2) state is

$$4(0,2)-4(1,0)+(1,0)-(1,1)+(1,1)-(0,3)=5.095\ [5.097]$$

Here is the missing measured excitation which can be fitted as

$$(0,2)-(1,3)=5.305\ [5.254]$$

but this disagree with assumed even structure of the excitations. We estimate the results as acceptable.

$19O$ first excitation is small, [0.096], and does not change the parity of ground state. For this reason the suitable candidate for this transition is

$$2(2,1)-2(0,4)=0.126\ [0.096]$$

Ground state of 19O takes as

$$4(0,0) + 9(0,1) + 4(0,2) + 2(2,1)$$

Needing subtraction, 5.779 leaves (0,4)=6.202 and (1,3)=5.788 states in real domain. However, the transition

$$2(2,1) - (0,4) - (1,3) = 0.539$$

as well as the next possible excitation was not observable. On this ground we accept that, because of model roughness, the (1,3) state is in the resonance field. Next excitations involve the nucleons of (0,2) state. Assuming the even number of nucleons take part in lower transitions we get

$$2(0,2-1,0) = 1.438 \text{ [1.471]}$$

$$2(0,2-1,0) + 2(2,1-0,4) = 1.564 \text{ [1.471]}$$

$$3(0,2-1,0) + 1(2,1-0,4) = 2.220 \text{ [2.371]}$$

$$2(0,2) - (1,0) - (1,1) = 2.691 \text{ [2.779]}$$

$$2(0,2) - (1,0) - (1,1) + 2(2,1-0,4) = 2.817 \text{ [2.779]}$$

$$4(0,2-1,0) = 2.876 \text{ [2.779]}$$

$$4(0,2-1,0) + 2(2,1-0,4) = 3.002 \text{ [3.067]}$$

$$2(0,2-1,1) = 3.944 \text{ [3.944]}$$

$$2(0,2-1,1) + 2(2,1-0,4) = 4.070 \text{ [4.109]}$$

Here were missing two observable excitations, [3.153, 3.231]. It can be

$$(0,1-0,2) + (2,1-0,4) = 3.358$$

that is the first excitation of (0,1) state nucleons.

On 20*O* lower excitations the expression is that they are caused by nucleons of (0,2) and (1,0) states. We suppose that (0,2) contains only neutrons while (1,0) two neutrons and one proton and the even type of transitions is allowed.

In this case the excitation of (0,2) always involve in the process the particles of (1,0) state. Suitable transitions are

$$(0,2-1,0)+(1,0-1,1)=1.922\ [1.675]$$

$$(0,2-1,0)+(1,0-1,2)=3.649\ [3.570]$$

$$(0,2-1,1)+(1,0-0,3)=4.061\ [4.072]$$

$$(0,2-1,0)+3(1,0-1,1)=4.466\ [4.456]$$

$$2(0,2-1,0)+2(1,0-1,1)=4.844\ [4.850]$$

$$(0,2-1,1)+(1,0-1,2)=4.921\ [5.002]$$

$$(0,2-1,1)+(1,0-2,0)=5.274\ [5.234]$$

Here the first and [4.456] excitations have one variant, the others can be achieved by few ways, we printed the nearest to observable transitions. Without the consideration of higher transitions the structure of ground state is unclear.

$21O$ database contains five numbers. One nucleon transitions from (1,0) state can fit first four of them as

$$(1,0-1,1)=1.298\ [1.218]$$

$$(1,0-0,3)=2.223\ [2.133]$$

$$(1,0-1,2)=3.032\ [3.026;\ 3.073]$$

Because the similar following transitions were not observable we take the compact configuration of ground state. Namely,

$$4(0,0)+12(0,1)+4(0,2)+1(1,0)$$

In this case the subtraction 6.2 close (2,1)=5.922 and leaves (2,0)=6.691 state for excitation

$$(1,0-2,0)=3.329$$

which was not observable. So this excitation is suppressed or this discrepancy is the effect of model flaw. The five observable excitation can be fitted as

$$(1,0-0,2)+(1,0-1,1)=4.681$$

$$(0,1-1,0)+(1,0-1,1)=5.232$$

$$(4.681+5.232)/2=4.956\ [4.927]$$

and so it is the doublet that can be checked. On the transitions from lower states because of their filling, we expect the excitation of four nucleons at once. Even so the lowest transition from (0,2) state was not observable.

$22O$ chosen ground state is

$$4(0,0)+12(0,1)+4(0,2)+2(1,0)$$

For this configuration the needing subtraction, 5.714, leaves (2,0)=6.383 state and close (2,1)=5.655 within the excitation set. Possible transitions restrict assuming that even number of nucleons take part in the interaction. First series of excitations, which is not lowest, is

$$2(1,0-1,1)=2.664\ [absent]$$

$$2(1,0-0,3)=4.658\ [4.582]$$

$$2(1,0-1,2)=6.142\ [5.800]$$

$$2(1,0-2,0)=6.586\ [6.509]$$

Next series include the neutron of (0,2) state on which we assume that it pick up the neutron of (1,0) state and both they are placed on the upper state. It is

$$(0,2-1,1)+(1,0-1,1)=3.091\ [3.199]$$

$$(0,2-0,3)+(1,0-0,3)=5.077\ [4.909]$$

$$(0,2-1,2)+(1,0-1,2)=6.561\ [6.509]$$

$$(0,2-2,0)+(1,0-2,0)=7.005\ [6.936]$$

This is acceptable result.

For next Z=8 isotopes the excitation database is empty.

The looseness of selected nuclei spectra is less compare with the ones for mirror nuclei. It can be estimated as a sign on the more complicated dependence of the gluonic subtraction upon the mass number. And the dependence of pionic field charge on the p-n difference can be the question also.

Simplest pionic potential, which gives $G^2 exp(-2a/R)$ effective potential energy, was simplified at once as $g^2(1-2a/R+2a/R^2)$, it is just the Kratzer potential [24], to get the visible expression for nucleon energies in pionic field. Such cutoff of a potential on the big distances with following extention of the one on whole R-axis is typical for theoretical physics because about the properties of a potential in point R=0 nothing is known, the Coulomb potential is well example of this statement.

Because of pionic field spherical symmetry, the real inertial forces did not appear as well as virtual inertial forces generated by w-field for space-like type of w-field potential in the pionic field of a nucleus. Alike to interaction of the magnetic field with magnetic momentum of a particle the space-like w-field can act on the mechanical momentum of a particle, by quality it is the spin-orbital interaction and can be added in as well as out to usual spin-orbital interaction.

In this model, anyone can find the questions which must be solved and the impression is that since Becquerel time the nuclear theory still is on the first degree of development.

If here are some printed errors, such as (0,1) instead of (1,0), informed me about the ones because two similar misprints were found by myself and they were reinstated after retyping; of this type errors happen not rarely, the example is the attempt of inserting the cite on S. Lang textbook.

6.4 Spin-orbital interaction in pionic field

In two-dimension matrix form of Dirac equation the term, which was neglected,

$$\vec{e}_R V'_P = \vec{e}_R \frac{a}{R^2} exp\big(-\frac{a}{R}\big)$$

embody the spin-orbital interaction in pionic field.

Because of Clifford algebra usage, it is convenient the two-dimensional matrix equation for particle of half one spin multiply from left on conjugated spinor and so work with matrices. For angle part of wave function there are two independent matrix-solutions [3] with opposite parities, $\vec{e}_R S(\theta,\varphi)$ and $S(\theta,\varphi)$, they are connected by angle part of the gradient operator

$$\vec{\nabla} = \vec{e}_R \partial_R + \frac{T}{R}$$

as

$$T\vec{e}_R S = kS; \;\; TS = (2-k)\vec{e}_R S$$

where the coefficient $k = \{-l,\ l+1\}$ for $j = \{l+1/2,\ l-1/2\}$. Hence with switched off spin-orbital interaction the states are parity mixed.

Wave function takes as

$$\Psi_{up} = F_1(R)\vec{e}_R S + F_2(R)S,$$

the dependence of $\vec{e}_R S$ on the jointed Legendre polynomials is

$$\vec{e}_R S = \left[P_l^m(\theta) + i\vec{e}_\varphi P_l^{m+1}(\theta)\right] exp(im\varphi\vec{e}_z)$$

The equations for radial parts of wave function are

$$F_1'' + \frac{2}{R}F_1' + V'F_2 = \left[\frac{k(k-1)}{R^2} + m^2 - E^2 + V^2\right]F_1$$

$$F_2'' + \frac{2}{R}F_2' + V'F_1 = \left[\frac{(k-1)(k-2)}{R^2} + m^2 - E^2 + V^2\right]F_2$$

and it is the sequence of pseudochiral nature of pionic field. In potential energy of the nucleon in pionic field, $V^2(R)$, and the derivative, $V'(R)$, hold the main parts, namely

$$V^2(R) = G(1 - \frac{2a}{R} + \frac{2a}{R^2}); \quad V'(R) = \frac{Ga}{R^2}$$

In this case the solutions of the equations are visible - unknown functions differ by constant multiplier, namely

$$F_2 = sF_1$$

where

$$s = k - 1 \pm \sqrt{(k-1)^2 + G^2a^2}$$

From physical reason, if the charge of pionic field runs to zero the spin-orbital splitting must disappear. Correspondingly, for j={l+1/2, l-1/2}

$$s_\pm = \mp\left[j + 1/2 - \sqrt{(j+1/2)^2 + G^2a^2}\right]$$

The expressions for nucleon binding energies are the same as in case $V' = 0$, but extended orbital momentum, it is the B-coefficient, is modified as

$$B_\pm = -1/2 + \sqrt{(l+1/2)^2 + 2G^2a^2 + s_\pm}$$

so the binding energy of j=l-1/2 state is bigger of the one for j=l+1/2 state. In case of the nucleon zero orbital momentum the j-1/2 state is absent.

Clearly, spin-orbital energy is small only for border situations when or $j \gg Ga$ or vice-versa. The fit of light nuclei structure made in previous subsections shown that typical order of the dimensionless pionic field charge is unite but the spin-orbital splitting was not emerged that means the presence

of some suppression mechanisms for SO interaction. Such outcome can be carry out by the nucleons pairing. In case pairing of identical nucleons they have equal orbital moments and opposite spins that drop-off SO-splitting of the levels. In case proton-neutron pairing these particles have equal as orbital moments as spin projections. However, the nucleons in isolated nuclei carry their quantum numbers and we can assume that the proton and neutron in the pair interact with neutral pions only; this means the signs of $V'\vec{e}_R$ term in the equation for upper part of nucleon wave function in pionic field are different that decrease SO-splitting for proton-neutron pair. Because both nucleons in proton-neutron pair can be or in j=l+1/2 or in j=l-1/2 state it leads to additional mixing of electromagnetic and pionic SO-splitting. For single nucleon excitations SO-splitting can be presented if the mass interaction with w-field, for which the main part of in-nuclei potential is $\sim a/R^2\vec{e}_R$ and which is jointed with the impulse in Dirac equation, does not suppress the splitting of single nucleon levels.

This pulls reconsidering the structure of light nuclei.

7 Gluonic field

7.1 Free gluonic field

By physical meaning the gluonic field is primary field that binds the quarks in a hadron. Similarly to electromagnetic field this is four vector field with gradient symmetry and with four potential $G(x) = G_0\gamma_0 + G_n\gamma_n$ which is restricted by Lorentz gauge condition.

Physical differences with electromagnetic field are following. Electromagnetic field may exist in three forms: as charged electric field, as not charged magnetic field and as transverse waves while gluonic field always exist as charged field. On infinity the electrostatic field disappears, on small distances both the linear and nonlinear Coulomb potentials have singularity. Gluonic forces, as it is thinking today commonly, do not vanish on infinity. Gluonic potential has no singularities in center of field, moreover, here the forces vanish that is known as asymptotic freedom of strong interactions. As for any physical quantity these properties of gluonic field and the field existence itself are grounded on data and their theoretical interpretations.

We regard the gluonic field as classical object in static spherical symmetrical state. The potential of the one is $G\gamma_0 = g(R)$

Simplest state of any field is the free field. In classical physics, the lagrangian of free field always is square form of field tensions. If we take such

lagrangian

$$L_0 \sim (\overrightarrow{\nabla} g)^2$$

then we get the Coulomb-like potential

$$g(R) = g_1 + \frac{g_2}{R}$$

which has infinite self-energy on small distances. Due to asymptotic freedom of strong interaction just the free gluonic field act in area of small distances and so the Coulomb-like potential is not being the potential of free gluonic field. We must accept that lagrangian of free gluonic field has more complicated form. If the one depends upon field tension only, then another, not Coulomb-like, solution of variation task exists. It is

$$(\overrightarrow{\nabla} g(R))^2 = constant$$

and it has no matter how complicated is the lagrangian of free field. In this case the potential of free gluonic field is following

$$g(R) = g_1 + g_2 R$$

where the constant g_2 determinate the scale of strong forces. It is fundamental quantity similar to electric charge in electromagnetic interaction. Remark, this is not faultless because it is general result and the unknown fields may exist.

As application example, regard the bound states of a particle in this field. Gluonic field tie up only the quarks but for simplicity regard a scalar particle in this field. For particle with mass m, energy E and orbital momentum l the Klein-Gordon equation for radial part of wave function is following

$$F'' + \frac{2}{R}F' = \left[\frac{l(l+1)}{R^2} + m^2 - (E - g_0 - bR)^2\right] F$$

Effective potential energy goes to minus infinity on big distances so this field is the unrestricted source of kinetic energy. If we do not believe in existence of the one then virtual inertial forces need take into account.

Yet, we regard free gluonic field. Radial part of particle wave function takes as follow

$$F(R) \sim R^l \prod_0^N (R - R_n) exp(AR + \frac{1}{2}BR^2)$$

Here restriction $ImE < 0$ is needing because the full wave function contain multiplier $exp(-iEt)$.

The solutions exist if the condition

$$m^2 = -ib(2N + 2l + 3)$$

is valid. So in this field only resonances are being and the square of their masses have linear dependence upon own spin.

From experiment such connection between the mass and spin of resonances is known few ten years. Firstly the Regge-pole then string models of strong interaction were established taking this connection as base [9]. However, the simplest tools of semi-classical physics enable to sight on high-energy physics phenomena.

7.2 On a quark confinement

Gluonic interactions have unusual property known as confinement - the quark as well as a gluon, the quantum of gluonic field, - are not observable in free states. For gluon this is natural because the free gluonic field has infinite self-energy, this is similar to situation with scalar photons which are not being seeing because the free electrostatic field does not exist. Because the mass of a particle is finite the confinement of quarks is striking phenomenon. In quantum field theory special mechanisms evoked for confinement of the quarks, [14] and [15], they are obscure still. At that time, it is hard to have the doubts that the some dynamics for confinement is not presented in quantum mechanics. Here the example of confinement in quantum mechanics is given.

Let us admit that gluonic field in not free state is usual physical field, then on infinity the potential of the one can be written as

$$G(R \to \infty) = G_0 + \frac{G_1}{R} + ...$$

For simplicity put $G_0 = 0$ and the potential energy, $V(R)$, of a quark in gluonic field cut off as

$$V(R) = \frac{g_1}{R} + \frac{g_2}{R^2} + \frac{g_3}{R^3} + \frac{g_4}{R^4};$$

Using the Schroedinger equation, that is reasonably for heavy quark, find the states of the 'quark+gluonic field' system. For easy viewing the dependence of the system spectrum at all, not one by one, quantum numbers the 'exact' solutions are searching. So the potential $V(R)$ is considered as being true on whole R-axis.

It is conveniently, replacing $F' = fF$, convert the Schroedinger equation to Riccati equation and get

$$f' + f^2 + \frac{2}{R}f = \frac{l(l+1)}{R^2} + 2m\varepsilon + 2m\Big[\frac{g_1}{R} + \frac{g_2}{R^2} + \frac{g_3}{R^3} + \frac{g_4}{R^4}\Big]$$

where $c = 1$, $\hbar = 1$ and m, ε, l are the mass, binding energy and orbital momentum of the quark. In this representation the form of wave function is well noticeable. It is

$$f = D + \frac{B}{R} + \frac{A}{R^2} + \sum_{n=0}^{n=N} \frac{1}{R - R_n}$$

or

$$F = CR^B \prod_n (R - R_n) exp\big(DR - \frac{A}{R}\big)$$

where C, B, R_n, D, A are constants.

The case $D < 0$ reproduce the usual situation, we put $D = 0$. This restriction at once carries the condition $\varepsilon = 0$, and so the motion of a quark in gluonic field is free anywhere.

Nevertheless, the quark is binding. Indeed, in case $A > 0$ with condition $(B + N + 3/2) < 0$ the wave function is square-integrable and free motion of the quark take place in some middle area, on infinity as well as in center of the field the quark is unobservable. Uncertain physical meaning this situation has. May be the system is inaccessible for external strong interaction and so it is out of the hadron family. However, the same is not unlikely for any field and such wild situations are possible because for small perturbations the invisibility is typical property of any quantum system. Another interpretation is that the quark is a spectator. External perturbations do not change the quark energy, they modify the field energy. Here is the similarity to excitation of an electron on internal, not filled, shells in the atom if the energy of external electron is the constant. Of course, these do not mean the confinement. For realization of the one the spectrum of the system, it coincide with the gluonic field spectrum, must grow without limit when the numbers N, l increase. This is possible.

For calculation of two unknown constants A, B we have four restrictions from the central R^{-1}, R^{-2}, R^{-3}, R^{-4} singularities. The values of R_n constants are fixed by $(R - R_n)^{-1}$ singularities. Consequently, the parameters of gluonic potential are not all free, the two restrictions are on the ones.

All restrictions are:

$$A^2 = 2mg_4; \quad AB = mg_3;$$

$$2A\sum_n \frac{1}{R_n} = B(B+1) - l(l+1) - 2mg_2;$$

$$(B+1)\sum_n \frac{1}{R_n} + A\sum_n \frac{1}{R_n^2} = -mg_1$$

$$\sum_{k,\, k\neq n} \frac{1}{R_n - R_k} + \frac{A}{R_n^2} + \frac{B+1}{R_n} = 0$$

Summing the last equations we get

$$A\sum_n \frac{1}{R_n^2} + (B+1)\sum_n \frac{1}{R_n} = 0$$

Hence $g_1 = 0$, that is impossible for Coulomb field, but for gluonic field it is. Like situation is for intermolecular interactions because the potentials are similar.

Multiplied the last equations by R_n and summing we get

$$\frac{N(N-1)}{2} + A\sum \frac{1}{R_n} + (B+1)N = 0$$

The parameters $A > 0,\ g_2 > 0,\ g_4 > 0$ are regarding as unknown constants and so $B = B(N,l),\ g_3 = g_3(N,L)$;

After these simplifications the B-coefficient is

$$B = -N - \frac{1}{2} - \sqrt{(l+\frac{1}{2})^2 + mg_2}$$

For fixed N and big orbital momentum the B-coefficient is

$$B(l \to \infty) = -l,$$

this solution is unphysical for usual boundary conditions.

At first approach the excitations of gluonic field can be calculated as the average value of the field self-energies. Because of asymptotic freedom the main order of contributions to self-energies is

$$\int_R^\infty |g'(R)|^2 R^2 dR \sim R^{-3}$$

The $N = 0$ states are simplest for integration of R-degrees

$$\overline{R^{-1}} = \frac{2\|B\| - 3}{2A} \to \frac{l}{A};$$

$$\overline{R^{-2}} \to \frac{l^2}{A^2};$$

etc. The $g_3\overline{R^{-3}}$ and $g_4\overline{R^{-4}}$ terms have equal, $\sim l^4$, order and the suitable choice of g_4 constant makes the spectrum of field growing when orbital momentum of quark increase. Similar situation holds for the $N \neq 0$ states.

Hereby it is shown that in quantum mechanics the confinement phenomenon is possible, the boundary conditions are leading cause of its appearance, the growing of a field potential on infinity is unnecessary. Instead the some parameters of the field are not constants, a quantization of a field arise. The quark is spectator which does not take part in interaction. For electromagnetic and pionic fields the situation is opposite - the fields are the spectators with constant energy. These are because the free fields have different properties and so different boundary conditions exist. It will have interest if in some system the roles depend upon value of excitation energy.

The picture is much simpler of existing in quantum field theory that does not mean that it is more far from reality.

8 Clifford algebra

This is addition for reader who is not familiar with this algebra.

Any algebra is richer variety compare with vector space. In algebra the sum and the multiplication of elements with different algebraic structure are defined.

Is it possible the extension of the vector space variety to algebra? W. K. Clifford gives the answer in 1876 year. For this doing it is enough regard the coordinate vectors as matrices.

In physics, the space algebra L3 and the space-time algebra L4 are the essentials. Let us regard their properties briefly. Remark, from relativity principle it has no matter which coordinate system is using. But it became as standard to divide a vector on components. Which troubles this dividing create easy is seeing on example switching interaction of the electron with external magnetic field in quantum mechanics. We avoid such way. Then the flat coordinate system is using in general case (of course, the existence of the gravitation which deformed the space is ignored). Only when numerical calculations are doing the suitable coordinates are taking.

In space algebra the coordinate orts, $\vec{e}_n$, are equal to two dimension Pauli matrices with following properties

$$\vec{e}_n = \sigma_n$$

$$\vec{e}_i\vec{e}_k + \vec{e}_k\vec{e}_i = 0; \;\; i \neq k$$

$$\vec{e_n}^{\,2} = 1; \; n = 1, 2, 3$$

$$\vec{e}_1\vec{e}_2\vec{e}_3 = i1$$

The last matrix change sign at parity transformations so the imaginary unite of the complex numbers algebra at that time is the pseudoscalar of space algebra. Then general element in the space algebra is the sum of scalar, pseudoscalar, vector, and pseudovector.

The gradient operator in L3 algebra is following

$\overrightarrow{\nabla} = \vec{e}_n\partial_n$

Few examples of calculations in space algebra.

$\vec{a}\vec{b} = a_n b_k \vec{e}_n\vec{e}_v = \vec{a}\cdot\vec{b} + i\vec{a}\times\vec{b}$

$\overrightarrow{\nabla}(\vec{a}\vec{b}) = (\overrightarrow{\nabla}\vec{a})\vec{b} - \vec{a}(\overrightarrow{\nabla}\vec{b}) + 2(\vec{a}\cdot\overrightarrow{\nabla})\vec{b}$

$\overrightarrow{\nabla}R^N\vec{e}_z = NR^{(N-1)}\vec{e}_R\vec{e}_z = NR^{(N-1)}(cos\theta - isin\theta\vec{e}_\varphi)$

In algebra of space-time the coordinate vectors, u_n, are equal to four dimension Dirac matrices, $u_n = \gamma_n$, with following properties

$$u_i u_n + u_n u_i = 0; \;\; i \neq n; \;\; n = (0, 1, 2, 3)$$

$$u_0^2 = 1; \; u_s^2 = -1; \; s = 1, 2, 3$$

$$u_0u_1u_2u_3 = i_c$$

The last matrix change sign at inverse of the space as well as time directions, the standard is to denominate the one as $i\gamma_5$ matrix. We use almost the denomination of G. Casanova because here are two pseudoscalars which coincide at passing to space algebra. Remark, the existence of two pseudoscalars i, i_c in the space-time algebra commonly is missing as implicit standard. De facto the space and the space-time algebras are the complex varieties. General element in the space-time algebra is the sum of scalars, pseudoscalars, four vectors, pseudo-four-vectors and bevectors.

If A, B are two four vectors then bevector F is external multiplication of the ones

$$F = A \wedge B = \frac{1}{2}(AB - BA)$$

The matrices $e_n = u_n u_0$ are the four dimension anti-diagonal representation of Pauli matrices. So any bevector has other form

$$F = \vec{V} + i_c \vec{H}$$

where $\vec{V}$, $\vec{H}$ are the space vectors in four dimensional representation. This property makes easy the crossing between the space and the space-time algebras.

The gradient operator in L4 algebra is following

$$\nabla = u_0 \partial_0 - u_k \partial_k$$

$$\partial_0 = \frac{1}{c} \partial_t$$

With common convention about the phases of physical quantities the operator of four impulse is

$$\hat{p} = i\hbar \nabla$$

Note that the definition of this operator with opposite sign is using widely.

Few examples of calculations in this algebra

$$\nabla A = \nabla u_0 u_0 A = (\partial_0 - \overrightarrow{\nabla})(A_0 - \vec{A}) = \nabla \cdot A + \nabla \wedge A$$

$$\nabla \cdot A = \partial_0 A_0 + \overrightarrow{\nabla} \cdot \vec{A}$$

$$\nabla \wedge A = -\partial_0 \vec{A} - \overrightarrow{\nabla} A_0 + i_c \overrightarrow{\nabla} \times \vec{A}$$

For more details see any textbook on Clifford algebra, for example [3] and [12], the links are in [11].

9 As summary

This article contains few news. The coherence condition and the direct solution of Dirac equation are technical tools. The w-field conception is physical assumption and it is working. Remark that any field has this w-field as shadow. We may regard this model as a description of virtual states in classical physics, especially if the local four impulse take as potential of w-field. However, in quantum field theory the local four impulse is the variable of integration but not the potential of a field.

The methods for elimination of the divergences of classical theory may be different [10]. For electromagnetic field the continual extension of classical field theory is almost trivial. For nucleus forces in simplest case the situation is even simpler than for electromagnetic field. However, for mechanical medium the model is not extension, it is another way and by this or other manner this needs doing because the mechanical interaction travel with finite velocity.

Also in general case the density of energy in any physical field is not zero so one more shadow, however scalar, field may exist. Therefore, no one feedback may be in any physical field, just the free gluonic field example uses this circumstance. J guess these will have interest for physicist and will be useful.

10 To free physicists some proposals are making

Sturm – Liouville oscillation theorem

If the Sturm-Liouville oscillatory theorem is true anywhere then solving of Dirac equation for radial wave function can be reduced to algebraic task. From unknown reasons such method is not using. Maybe because the scientists, as any, inclined to go by common roads; maybe, I think, because the spectral, which is base, S-L theorem was proved for finite valued functions. Real potentials, they are spherical symmetrical mainly, are jointed with centrifugal term, $l(l+1)/R^2$, which is infinite on small distance. It will be well and well achievement if S-L oscillation theorem extend in area of real potentials. In last two years in this direction somewhat was made but for finite functions and intervals only. It seems a fresh glance needs here if we are not in the Godel area that is typical for theoretical sciences.

Gravity

For outsider the theoretical dealings with classical gravitation field look as swimming in the sea of indexes. Because for fermions the space-time is the Clifford algebra we can expect that for any systems this will be true. In my opinion, the presentation of the gravitation theory in Clifford form will be useful. On first look to do this is not hard. Indeed, any tensor, G_{ik}, is possible rewrite as A_iB_k. Then in Clifford algebra

$$G = AB = A \cdot B + A \wedge B = s + \vec{e} + i_c\vec{h}$$

is the sum of scalar and bevector, the last itself is the sum of three vector and pseudovector. After taking the suitable coordinate system the independent quantities are: s; v_x; h_x; h_y, just four parameters as for symmetrical tensor. The emergence of scalar field, s, does not bring a joy, it is enough the sigma

meson in nuclear physics and Higgs in high energy physics. Maybe this scalar field is possible to avoid. Switching to other formalism is not empty work; on example of fluid dynamics is clearly that the appearance of new items is possible.

Another question concerns to electro-gravitation. This branch of gravitation theory is neglected by community entirely. This is because any vector field change sign at charge conjugation. But this assertion is no more than a convention. For example, looks on linear and nonlinear Maxwell equations for electromagnetic field

$$\nabla F = eu$$

$$\nabla F = gFuF$$

At charge transformation, $F \to -F$, the two possibilities are here:

or

$$u \to -u,\ g \to g,\ e \to e;$$

or

$$u \to u,\ g \to -g,\ e \to -e;$$

Because the fourvelocity is dimensionless quantity the second case has preference, I always use the last definition. Commonly the first case used by the implicit convention. The parameter u, which is the local fourvelocity of gravitation field when this field is regarding, can help to extend the gravitation theory and even rewrite the one in electro-gravity form, says in form of Maxwell equations.

Atomic physics

Here the theory is far away of experiment, the looks on the data and theoretical calculations of the ones is enough to comprehend the situation. Also here are some questions which should have resolved many years ago. One of them is the description of spin-spin interaction for simplest, spin half one, case. Here usual basic tool is the σ_z matrix. In Clifford algebra for spherical symmetrical field it is the $\vec{e}_R$ matrix. Because the spin is relativistic object $\vec{e}_R$ can be regarded as stemming from or γ_R (that correspond to vector part of electromagnetic potential) or $ii_c\gamma_R$ (this is connected with scalar part of potential) matrix. In first case the PT properties are wrong, additionally and mainly, for system with electric charge at least the local coordinate system

exist where the vector potential is vanished while the spin is not equal to zero in any system. In second case PT-properties are true and s-s interaction is jointed with electrostatic potential. Such approach can be applied for data fitting but the construction of general relativistic form for description of s-s interaction is desirable.

Nuclei

The conception of self-consistent field was built on the base of mechanics and it is hardly compatible with relativity, locality and causality principles. Another approach, created by Faraday and developed by Mie, when the field regards as the basic quantity, is rarity in physics (it seems that the Skyrme model is the unique example of working tool). Extended Yukawa potential of pionic field is pure field object which has no less firm ground than any potential in the physics. In my opinion it need making the efforts for clarifying: the dependence as gluonic as pionic potentials on proton and neutron numbers; the real contribution of Coulomb force in binding energies; the emergence of mass forces. Either independent-particles or fields itself picture is real this belongs for essentials; if the computation tools permit the simultaneous comparison of two approach will have been making at data fitting. For education process extended Yukawa potential is fruitful.

In addition, from many and different reasons this article becomes long, invisible and hard for reading. If a reader gives to me the endorsement in physics or nucl-th parts of arXiv.org I will be grateful to him.

11 Acknowledgment

The author would like to thank Dr. Andre A. Gsponer for given possibility upload this article in arXiv.org.

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